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PARENTY'S APPARATUS FOR FLUSHING SEWERS.

THE problem as to the cleaning of sewers is one of the most important that a commission of public ways has to solve, since it interests both public hygiene and cleanliness. Self-priming siphons have hitherto been employed for this purpose, but Mr. Henry Parenty, a French engineer, proposes an apparatus whose operation is based entirely upon the variation in weight of a body according as it is or is not immersed in water.[1]

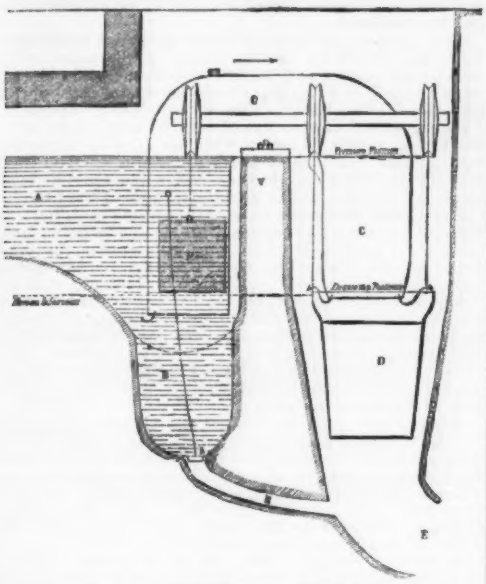


FIG. 2.—VERTICAL SECTION.

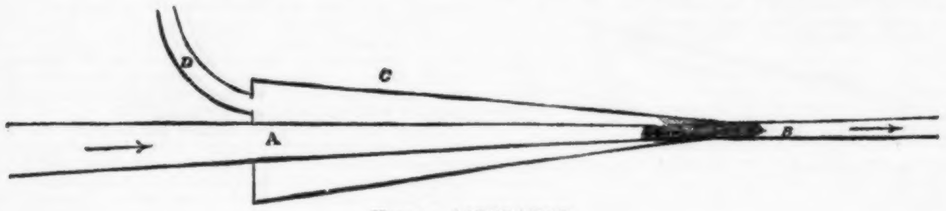
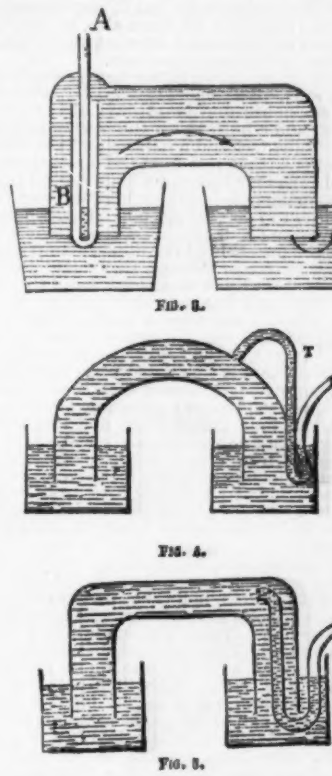


FIG. 6.—ASPIRATOR.



FIGS. 3-5.—METHODS OF PRIMING.

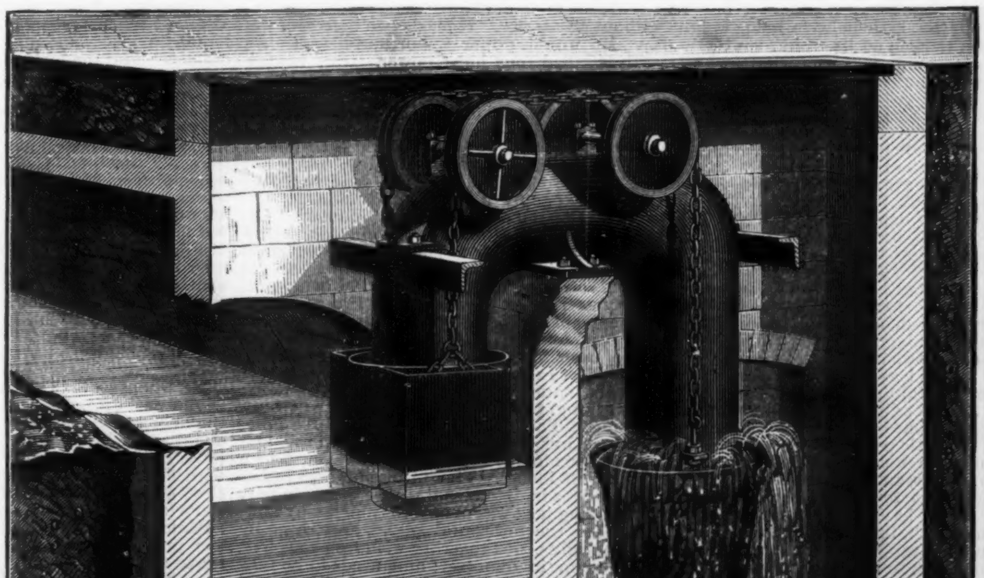


FIG. 1.—PARENTY'S APPARATUS FOR FLUSHING SEWERS.

The diagram in Fig. 2 will allow the operation of the apparatus to be understood. The device consists of a siphon, of large diameter, and of any section desired, which is primed in advance by various processes that we shall mention further along. One of the legs dips into the race, A, which is of wide area and slight depth and terminates in a drain-well, B, and is separated from the basin, E, by a vertical partition, V. The second leg debouches in a movable collector, D, whose upper part is widened so as to facilitate the exit of the liquid and render the swinging point more accurate. This collector is capable of moving vertically by means of chains, from which it is suspended, and which run over pulleys, keyed to a horizontal shaft. These chains communicate motion to a second train of pulleys, from which is suspended a counterpoise, P, which dips into the race, and whose actual weight in the air is greater than that of the collector full of water, while when entirely submerged it is less. It will hence be seen that the variations of the race in level are capable of effecting an automatic descent of the collector and an ejection of the liquid into the basin, over the collector's edges. The motion of the collector has the effect of lifting the counterpoise, and the apparent weight of the former consequently increases in measure as the water flows from the flushing basin. When the latter is empty, the counterpoise descends again, and carries along the collector and places it in its former position. As the feeding of the flushing basin is permanent, it results that successive flushings are obtained, whose frequency is proportional to the amount of water discharged.

In order to facilitate the exit of the liquid and avoid friction, the movable collector is given the form of a truncated cone, whose larger base is above; and the leg of the siphon which enters it has an identical form, and exactly fills all the space therein when the collector is in its highest position. When the collector reaches its lower position, the water escapes with violence through the lower leg of the siphon, and spurts to a great height over the edges. The velocity with which the liquid makes its exit increases with the height of the water in the flushing basin, and becomes *nil* when the latter is empty. By reason of the velocity acquired, the level of the water in the basin descends a few fractions of an inch beneath the upper edge of the collector, and hence the necessity of prolonging the upper leg of the siphon about 4 inches beneath the theoretical minimum level. In the ascending motion of the collector, the velocity of the liquid takes a contrary direction in the siphon. The collector gives up to the flushing basin the water that it contains, and hence becomes lighter and lighter. There forms, then, an ascensional force, which is, it is true, counterbalanced by the immersion of the counterpoises, but which is capable of producing a strong shock on reaching home. This drawback, which in nowise destroys the apparatus' operation, may be obviated either by causing the ascensional motion of the collector to begin an instant before the loss of velocity in the liquid contained in the siphon, or by causing the counterpoise to enter a masonry well of a diameter nearly equal to its own, thus forming a hydraulic brake of great power. For the variable action of the counterpoise there may be substituted the action of a siphon placed in the movable collector and priming itself automatically during the emptying of the latter. As the collector then becomes lighter, it can rise to its upper position.

Such is the principle and the mode of operation of Mr. Parenty's siphon—an apparatus which offers absolute security, and permits of discharging with great velocity a mass of water designed for flushing a sewer.

Priming of the Siphon.—As shown in Figs. 3, 4, and 5, several processes of priming may be employed. For example, we may use a counter siphon formed of a vertical tube, A, that debouches in the open air, and runs to the bottom of a cylinder, B, closed at the bottom and placed in the interior of one of the legs (Fig. 3). When all the air has been sucked out by means of the mouth or otherwise, the cylinder will fill with water and thus form a perfect hydraulic joint.

We may likewise have recourse to a tube, T, of small diameter (Fig. 4), which is doubly curved, starts from the top of the siphon, descends beneath the lowest level of the water in the apparatus, and opens in the air above the highest level. If it is not desirable to make an aperture in the siphon, this second method may be arranged as shown in Fig. 5.

In order that the priming may be kept up without surveillance, when the siphon is fed by pure water, it has occurred to Mr. Parenty to use a small aspirator, analogous to the Giffard apparatus and actuated by the feed water. Fig. 6 shows the general arrangement of this. The liquid, entering at A, makes its exit through the cone, B, the entrance to which is a little smaller than the exit of the tube, A, and which widens out in a contrary direction. The two orifices are separated by an interval of a

small fraction of an inch. Finally, the cone, C, incloses the two tubes, A B, and receives one of the extremities of the suction tube, D.—*Le Genie Civil.*

WELL-BORING BY STEAM WITH A SPRING-POLE.

By Benjamin Smith Lyman.

Until about 1878, the use of the spring-pole, so convenient in boring deep wells of two inches or two and a half in diameter by hand, was impracticable with steam-power, owing to the violent jerking action of the pole that would have shaken a machine to pieces. But at that time, the difficulty of employing steam was first successfully obviated by adding what is called "the little-pole," invented, it is said, by Job Evans, a Welshman; and now in general use in Northeastern Ohio and perhaps elsewhere. There was no patent to hinder; and if there had been, it might possibly have been evaded by using some other kind of spring, such as a soft wagon-spring. The following account is prepared from observation in September, 1884, of the practice of Mr. John Shoaf, of Coalburg, Trumbull County, Ohio, an experienced driller of wells in that region, and from information given by him. Some of the tools and arrangements are not by any means peculiar to the use of steam with a spring-pole; but it may be worth while to make brief mention of them also, as a more complete guide or as a reminder of what very recent practice finds best after long experience.

His little-pole (as shown in the figure) was 15 ft. long, "middling long," four inches in diameter at the forward end, and two inches and two-thirds at the other; and hung a foot and a half below the spring-pole by two clamps, one nine feet and a half behind the other, and the forward one three feet from the forward end of the pole, which was four feet and a half behind the upper end of the spring-pole and the bore-hole, and was attached to the top of the pitman. The length of the little-pole varies; a length of sixteen feet is "plenty long;" but the part behind the hinder clamp is unnecessary, so that twelve or thirteen feet would do.

The forward clamp was an iron band three inches and a half wide and five-eighths of an inch thick, open at the top, where it extended a couple of inches above the spring-pole, and was tightened by two small bolts with nuts. It was closed below the little-pole, but in Mr. Shoaf's opinion it would better be open there too, so that it might be tightened with screws and nuts. The space between the two poles was filled by a block of wood about four inches thick and about eighteen inches long, with two wooden wedges above to tighten it. A couple of iron pins, one before and one behind the iron band, loosely keep the block in place.

The hinder clamp is simply two iron bands two inches wide by three-eighths thick, fitting the spring-pole above, and united at the top by a small bolt with a nut screwed tight, and tightened in like manner just below the spring-pole, but so as to leave a space of about three inches between them, in which the little-pole rests between two bolts that pass through two out of four pairs of holes in the bands and leave some play for the little-pole. There is a small iron pin passing down through the little-pole just behind the lower of the two bolts, and hidden in the figure by the nearer iron band of the clamp. The little-pole must not be wedged tight there; but a weight may be suspended from the hinder end of the pole, such as a chain, with or without a heavy piece of iron laid in a loop of it, to prevent the pole from jumping too violently; and to keep the chain from sliding off, a wooden pin passes through the little-pole near its end. Sometimes, instead of a clamp of that kind, there is a long iron pin that passes vertically through the spring-pole and is strung with round blocks of wood criss-cross, to keep the two poles apart.

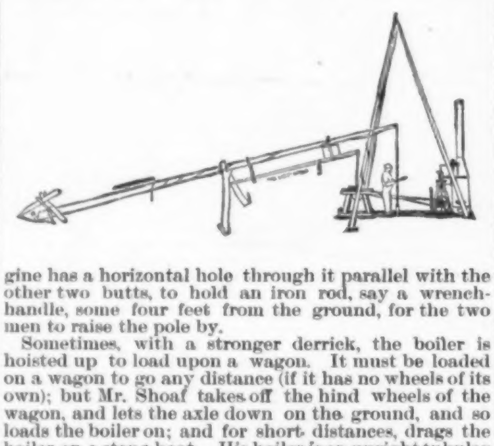
The forward end of the little-pole is bound with a wide iron band through which passes vertically a bolt with a screw and nut at the top, and with a fork below crossed by a three-quarter inch pin that goes through the head of the pitman. Behind the forward clamp, a loop of small rope hangs from the little-pole, to hold up the lower end of the pitman when off its crank, so as to allow of hoisting the sand-pump with the windlass. The little-pole is carried about from one boring field to another.

The spring-pole, however, is not carried any great distance, and is cut fresh for each field. Ours happened to be forty-two feet long and about ten inches in diameter at the butt and four at the top; though Mr. Shoaf would prefer one of about fifty feet. But the length of forty-two feet was enough for holes 200 ft. deep, and too great for the shallow holes in hand at the moment. The pole was of beech, but ash is a very good material, and so is hickory. At the butt, it was held to the ground by a couple of stakes about four feet long, in notches cut in its sides at a foot from the end, and a couple of small loose logs were laid as weights upon the stakes to keep them in position. The spring-pole was set at an angle of about fifteen degrees with the horizon, resting at about twenty-two feet from the butt upon two props of forked logs, at right angles with one another and about at right angles with the pole. The props, called "the forks," then, were just behind the little-pole, but sometimes they are placed between the two clamps of the little-pole. They were placed quite behind, because the holes were shallow and the boring-rods therefore light, and greater springiness was needed in the somewhat too heavy spring-pole. The forks were set about half a foot into the ground, and one, or sometimes both, had a stake driven in below, to prevent settling too deep and to aid in the adjustment of the spring-pole so as to bring the upper end exactly over the bore-hole.

The upper end of the pole was cut off just above a natural fork, and was so laid as to make a vertical notch, that was enlarged by burning with a hot iron to 1¾ inches wide and 2½ inches deep, so as to let the chain slide easily through, from which hung by a hook at the end the drill-rods with a swivel at the top, seven inches high by 5½ inches wide and an inch thick. The chain was of one-quarter inch iron in links an inch and a half long, and was about 24 ft. long, with a rope about ten feet long at the outer end; and it was wound around the spring-pole in very long loose coils near the upper end, but in shorter, tighter ones further down. The jerking of the rods gradually tightens the loose coils at the top, and as the hole deepens, the chain is let out more and more; and no temper screw is used.

The rods were in general 13 ft. long, but a length of "12 ft. is plenty;" and they can be used in pairs, unscrewing only every other one. The sinker-rod, the first one to which the bit is attached, was 14 ft. 7 inches long and 1⅝ inches in diameter. Some short pieces of rod are needed; one of three feet and one of six feet would be convenient, and together they would be nine feet, and could, as the hole deepens, be replaced by one of 12 ft., the full length. The swivel should be attached to a piece about 9 ft. long; a short swivel is always making bother by striking its collar against the top of the pipe inside which the rods move, and which rises a foot or so above the surface of the ground. Each rod has a collar about an inch long at half a foot to a foot from the upper end, so that the iron fork or "sow" may catch there and hold the rods while unscrewing. The space from the collar up to the shoulder just below the screw at the end of the rod is one inch square, to receive the wrench. The rest of the rod is round, except a short square place for the wrench close above the socket at the lower end. The screw at the upper end of the rod is 1⅝ inches long by one inch in diameter. For screwing or unscrewing, one long heavy wrench is taken in each hand, and caught on the rods near the joint, the left hand above for unwrenching and below for tightening, and then with jerks the hands are brought toward each other. This apparatus answers for holes 300 ft. deep; but for a greater depth, so much time is lost in screwing and unscrewing that a rope and jars must be used, though with greater difficulty in recognizing the character of the material bored through.

A derrick, then, without the use of the rope and jars, is only necessary for hoisting the rods and pipe and the sand-pump, and for these holes of small diameter is a light, movable affair. It is simply three poles 24 ft. long (a foot less is "plenty"), four inches and a half in diameter at the butt, and less than two at the top, and stand about 14 ft. apart at the butt. Mr. Shoaf's poles were of maple, and had served three years. They are bound with iron at the top, and have a hole there an inch and a quarter in diameter, at six inches from the end, for an iron pin, 25½ inches long by ¾ inch in diameter, which unites the three poles. From the pin also hangs the iron pulley, of eight inches in diameter and 1⅜ inches wide in the clear, for a hempen rope 1⅛ inches in diameter. A little below the pin, a ring of rope rests loosely upon the three poles, and the double lengths of rods, sometimes with a swivel at the top, are pushed through the ring when hoisted out of the bore-hole, and so, after unscrewing below, are stood upon the ground ready to be screwed on again and let down. Two men can set up the derrick, as, indeed, the whole work is attended to by the two. The pole near the en-



gine has a horizontal hole through it parallel with the other two butts, to hold an iron rod, say a wrench-handle, some four feet from the ground, for the two men to raise the pole by.

Sometimes, with a stronger derrick, the boiler is hoisted up to load upon a wagon. It must be loaded on a wagon to go any distance (if it has no wheels of its own); but Mr. Shoaf takes off the hind wheels of the wagon, and lets the axle down on the ground, and so loads the boiler on; and for short distances, drags the boiler on a stone-boat. His boiler is an upright tubular one, and with its engine weighs seventeen hundred-weight without any water. It needs two barrels of water a day. He would prefer a horizontal boiler on wheels. His is called four horse-power, "but is really about three and a half," with a piston four inches in diameter and six inches stroke; yet has bored 208 ft. deep without difficulty. It is the pulling up of the rods that needs the power, and that could be arranged for greater depths with a bigger wheel and a little loss of time. Still, Mr. Shoaf would prefer a six horse-power engine, the next size larger. Any engine of sufficient power will do, say one for a thrashing-machine.

The belt-wheel of the engine had a diameter of ten inches, and with a belt 3⅜ inches wide moved the belt-wheel of the windlass or "jack," 13½ inches in diameter, with the jack seven feet from the engine, a measure that is of course unimportant. The belt-wheel of the jack by gearing on the same axle, 18 teeth to 58, moved the axle of the crank of the pitman; so that there were about four revolutions of the engine to one stroke of the boring-rods. Sometimes the larger belt-wheel is three feet in diameter, and then cogs are not used. The rods made from 45 strokes (while the boiler pump was working) to 68 strokes a minute, or perhaps more sometimes. The pitman cranks had three holes 2½ inches apart, but the middle one was in use and gave a radius of six inches. The rods, however, had a stroke of about 18 inches. The pitman was 48 inches long and 1¼ inches in diameter through the main part of its length. The jack was of oak, four inches by four, planed down for the horizontal pieces, and three by four for the uprights, tied together with iron rods five-eighths of an inch in diameter; and needs to be very solid. It was three feet across by four feet long and 2¾ ft. high; but "should be only two feet eight inches across, so as to load into a wagon conveniently." It was held firmly to the ground by four forked stakes two feet and a half long and some three inches in diameter, and is braced well apart from the engine by a nearly horizontal bar of wood wedged tightly between the foot of the jack and an upright wooden bar set against the engine frame. The part of the axle of the pitman crank that is within the jack was five inches and a half in diameter, of wood, for the half-inch rope of the sand-pump or the larger rope of the drill-rods. Each axle has also a removable hand-crank of iron.

The "tackle-rope," for hoisting the drill-rods, is one inch or 1⅛ in diameter and about 37 ft. long, and has at the end an iron that is called either the "J-hook," from its shape, or the "grab-hook." This is shaped like a letter J viewed from the side, a foot long and four inches wide and an inch square near the upper end, but having the hooked part double, a fork 1⅜ inches wide by 2⅜ inches deep. It catches upon the boring-rods below the shoulder; and has a "tag-rope" a quarter of an inch in diameter and some fifteen feet long, to guide it by when high in the air.

In Northeastern Ohio, where the glacial drift, or "surface," is often very deep (sometimes 33 ft. or even more), a gas-pipe, 2⅜ inches inside diameter, is put down to the solid rock before the derrick is set up and the steam boring begun. To start with, an auger, 33 inches long by four inches in diameter, shaped in the main part (21 inches long and half an inch thick) like a carpenter's auger, but with a straight, steeply inclined cutting edge 3¾ inches broad, is used. Sometimes also, but rather rarely, when the auger cannot any longer be worked, a mud-pit is used 3¼ inches across the edge, for drilling in the surface before the pipe is put down. The iron rammer used in driving down the pipe is 4½ ft. long, two inches in diameter, besides a slighter handle about two feet long above a shoulder of 4½ inches in diameter and about two inches thick. The blows are given upon a piece of pipe 21 inches long, that is screwed upon the top of the rest to save them from getting battered.

The sand-pump was the same as usual with such holes, five feet long by 1⅞ inches in diameter, with wooden valve-gear and leather valve; and "should be of galvanized iron, so that it can be cut up if it should get fast in the hole." The iron "sinker" above it, "rather too short and light," was 33 inches long altogether, of which 25 inches were an inch in diameter with a "jar" or link at the bottom of a quarter-inch iron, three inches long in the clear, which must be bent so as to bring the sinker into the middle of the hole.

The "jars" for such narrow holes had each part 32 inches long, and two inches wide at the widest place, with a slit a foot and a half long, and were of the very best iron (Swedish); but they are used by Mr. Shoaf only for jarring a rod loose after unscrewing and removing as much as possible, and then screwing the jars on above. There was also a "grab," simply a tube for eight inches below with a sharpish edge somewhat flaring, to drive down upon a fallen rod to rescue it. Another grab, that costs $15, is also flaring, and inside has a left-handed screw-thread cut for grabbing a fallen rod, and even unscrewing it.

For the forge, besides a small anvil, there was simply a pair of blacksmith's bellows, 27 inches wide, fitting with its nozzle snugly into a piece of iron pipe two feet long, that reached to the middle of a temporary fire-place made with earth on some small knoll near each bore-hole. "A portable forge for drillers with revolving fan costs $16 or $18, and lasts longer than the bellows, and is more convenient."

A piece of chain, ten feet or less, of iron an inch in diameter and links three inches long, is used to put around the pipe for starting to hoist it when it is fast in the hole. Sometimes even the spring-pole is turned around and used as a lever with the chain fastened to its butt end. When the top of the pipe is only a couple of feet below the surface of the ground, it may sometimes be raised by driving a stake into it, winding a chain around the stake, and prying up by degrees until the chain can be put around the pipe itself, so as to hoist it with the windlass by hand.

There was a wooden handle for keeping the rods turning while boring, four feet and a half long and two inches in diameter at the ends and about 2½ inches square in the middle, and capable of being clamped to any place on the rod by a nut (with a strong iron wrench of its own, 19 inches long), upon an inch screw that passed through the middle of the handle, and with a hook at the other side pressed the rod against an iron plate (on the wood), nine inches long by 2⅝ inches wide and one-sixteenth of an inch thick.

There were two iron rod-wrenches, 2½ ft. long, shaped like a letter J, 1⅛ inches wide around the jaws, and an inch thick; a slighter, small wrench, about a foot long, of three-quarter inch round iron, for use when rods had already been loosened; an iron fork or "sow," with a handle a foot long and seven-eighths of an inch in diameter, and the fork at a very obtuse angle with it seven inches deep and flaring at the outer end, "rather answering."

Besides the tools already mentioned, there were a shovel, a crow-bar, an ax, an auger (1⅛ inches), a hammer and a coarse file for the forge, a gauge of iron plate for the bits (2⅜ inches, and, when the hole has become deep, 2¼ inches), a cold-chisel mounted as a hammer, a pair of pincers (jaws 2 inches by ¾ inch), about three wrenches for the various nuts, a monkey-wrench, an oil-feeder, an oil-jug, a wooden bucket, two headless oil barrels for water, a six-foot length of 1¼ inch rubber hose with perforated tin end about three inches long, for pumping water from the barrel into the boiler, a stone-boat for hauling water, etc., a tool-box (3½ by 1 by 1 foot) for the smaller articles, with a till, and "there ought to be a sledge;" also, "the water-barrel ought to have a pipe to warm the water in winter."

Mr. Shoaf's whole plant cost about $400, of which the engine cost $265, the jack $55, the forge bellows $6.50, the belt $4. A set of joints (socket and screw, with about six inches of rod adjoining) cost from 1882 to 1884, $2.50, but used to cost $4. Wells are bored ("drilled") with steam by contract in Northeastern Ohio for 40 or 45 cents a foot for the first hundred feet, and 20 or 30 cents a foot more for the next hundred, or even an advance of ten cents a foot for every ten feet beyond the first hundred. Mr. Shoaf and his partner have bored as much as 100 ft. in two days and a half, and 47 ft. in a single day; but that is very exceptional, and sometimes the rock is extremely hard.

Northampton, Mass., Dec. 3, 1885.

—*Eng. and Min. Journal.*

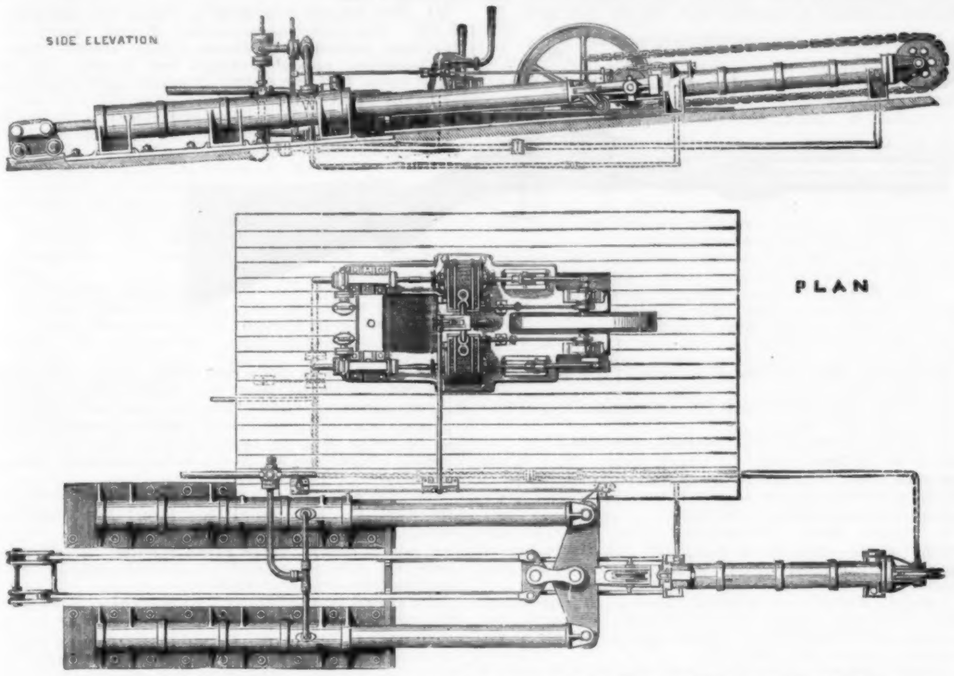
THE QUAKER DAM.

Chief Engineer Church has submitted the following reasons why Quaker Bridge Dam should be built: First, it is the surest and most expeditious means of securing the required storage; second, because it gives the best control of storage; third, because it will give the purest water; fourth, because it is the best safeguard against the stoppage of the city's supply by a possible failure of dams above, to the injury of the Croton Dam; fifth, because without it, the supply

of the whole watershed cannot be secured, and the size and cost of the new aqueduct will be rendered unwarrantable; sixth, because it best preserves healthful conditions for inhabitants in the Croton Valley, by keeping the bottom of the reservoir always covered, and prevents malarial influences.

HYDRAULIC SLIPWAY AT HIOGO.

We illustrate a set of hydraulic machinery for a slipway, which has been erected and set to work at the Imperial Japanese Government Yard at Hiogo. It was designed and constructed by Mr. H. J. Coles, Sumner Street, Southwark, for hauling vessels of 1,300 tons up a slipway having an incline of 1 in 20, and consists



HYDRAULIC MACHINERY FOR SLIPWAY FOR THE JAPANESE GOVERNMENT.

of a set of double rams coupled to a massive forged steel crosshead to which a smaller crosshead is coupled by heavy steel links. Wrought iron links are attached to the smaller crosshead, which are carried between and extend beyond the ends of the main hauling cylinders, the links being supported at their extremities by a carriage fitted with wheels running on rails. The cradle links are attached to the carriage. The crosshead and links are all connected by turned steel pins fitted in holes carefully and accurately bored out, so that a perfectly central and divided resistance may be met by each ram. The holes in the crossheads are also arranged so that, should either ram by any means precede the other during the operation of hauling, and thus throw the crosshead out of line, increased resistance would immediately fall on the forward ram and equilibrium be restored. The large rams have a stroke of 10 ft. 6 in., and the length of the cradle links is 10 ft. A smaller cylinder and ram fitted with a ram and bucket is fixed opposite the center of the crosshead connecting the large rams, for the purpose of returning the large rams, also for lowering the cradle and hauling it up when empty, the latter operations being performed by means of a strong chain passing under the cylinder and returning over the top, by which means the cradle can be moved 20 ft. at each stroke of the ram.

Pumping power is obtained by a pair of direct-acting horizontal engines having steam cylinders 15 in. diameter, and pumps of the ram and bucket type of 2½ in. and 3½ in. diameter respectively, the whole being suitable for a working pressure of 2,000 lb. per square inch, should this pressure be required. The engines and rams are manipulated by two levers placed in close approximation, one lever being coupled to the slide starting valve of the engines, and the other to an extremely simple form of valve for diverting the current of water from the pumps to either the large or small rams, according to the operation which is being performed. When working the empty cradle, the only alteration necessary is to close a stop valve on the pressure main leading to the large rams, and attach the hauling-up chain to the cylinder of the small ram. The *Engineer* says: Extremely satisfactory reports have been received of the working of this machinery since its erection in Japan.

IMPROVED STONE DRESSING MACHINE.

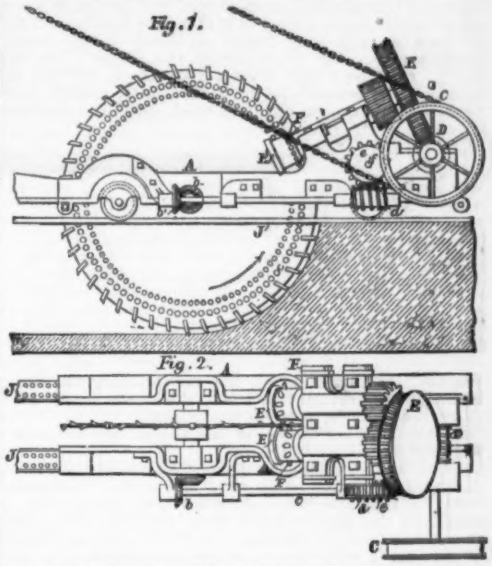
A novel form of stone cutting machine is just being introduced into England from America by G. D. Peter & Co., London, E. C., and is now erected in the yard of Messrs. Mowlem & Co., at East Greenwich. It is the invention of Messrs. Crump & Brereton, Philadelphia, and brings with it, says *Engineering*, a most favorable record, as by its use the price of stone-getting has been greatly reduced, and many formations which could not hitherto be put into the market at a price to command a sale, such, for example, as the hard American marble, are now being worked at a profit.

The idea upon which the machine is based is eminently simple, for the cutter blade is simply that of a heavy lumber saw with removable teeth. The novelty lies in so combining the parts as to drive this thin circular steel blade, unsupported by bracing, through stone to the depth of its radius, with a cut ⅜ in. wide; while the blade feeds forward at a rate adapted to the stone it is working in. The conditions to be met in making deep vertical fissures in solid beds of rock are very different from those which obtain in sawing logs. The most evident difference between the two is that there is no room for a driving wheel or pulley of adequate size, unless the depth of cut be restricted to about one-fourth of the diameter of the saw, and that even with this limitation, a very stiff and consequently a very thick plate would be required to transmit the power, as the rate of revolution is necessarily slow. Further, as the stone is fixed, the saw must be made to travel along, together with its gearing and motive power.

The methods by which the inventors have met these difficulties will be readily understood from the perspective illustration given below and the detail engravings. The large engraving is made from a photograph of the machine as it stands at East Greenwich, and shows the temporary character of the installation. In spite, however, of the apparatus being mounted on light and inadequate supports, it sawed the stone represented in the view with perfect steadiness and without tremor or vibration. The saw is driven from the periphery, and not from the center, and hence nearly the entire radius is rendered available for the depth of cut. This of itself is not new, as on page 274 of our seventeenth volume we illustrated a coal-getting machine which exhibited this feature, but with this difference, that the cutters were mounted on a heavy cast iron wheel and not on a thin plate. The driving power is applied at the part of the circumference where the blade emerges from the stone, and thus the metal is always in tension and has no tendency to spring or buckle; while, as the blade cuts upward, the pressure of the driving gear is downward, and the machine is held firmly down to the surface of the rock. The saw with its gearing, together with a small engine and boiler, is mounted on a traveling frame, which advances, as the blade revolves, on a tram track fitted with holes into which the pins of the feed wheels enter. The power is communicated from the crankshaft of the engine by a friction chain belt to a pulley, C, at the opposite end of the framing. This pulley transmits the power through the worm, D, and wormwheel, E, to two parallel inclined shafts, each of which carries at its lower end a ring of teeth, F, and a plain collar, E. Each of these teeth gears with the ring of holes cut near the circumference of the saw disk, while the collar forms a support against sidewise deflection.

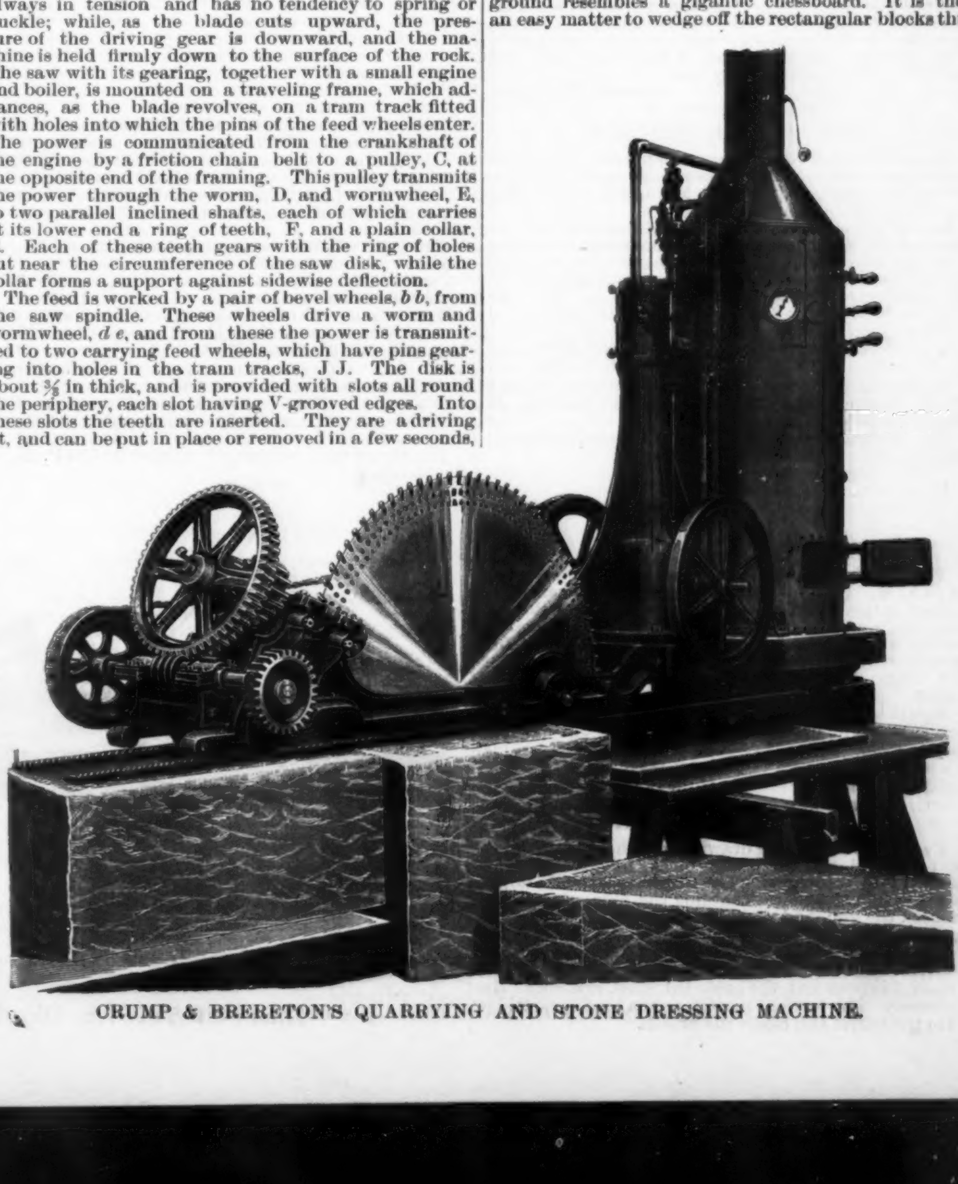
The feed is worked by a pair of bevel wheels, *b b*, from the saw spindle. These wheels drive a worm and wormwheel, *d e*, and from these the power is transmitted to two carrying feed wheels, which have pins gearing into holes in the tram tracks, J J. The disk is about ⅜ in thick, and is provided with slots all round the periphery, each slot having V-grooved edges. Into these slots the teeth are inserted. They are a driving fit, and can be put in place or removed in a few seconds. Indeed, it is possible to take out a set and replace them as the saw runs. The form of the teeth depends upon the nature of the stone to be cut; they are usually right and left handed alternately, each fifth one being straight, and in appearance they recall the steel cutters used in certain forms of tool-holders employed in lathe work. The amount of grinding required by the teeth is a subject of prime importance in calculating the cost of working such a machine. It is stated to vary from once a day to once a month, according to the material cut. The man who drives the engine also attends to the cutters.

The block of stone shown in the engraving measures 30 in. deep by 36 in. wide, and was cut, dry, completely through in our presence in thirteen minutes, or at the



CRUMP & BRERETON'S QUARRYING MACHINE.

rate of 2¾ in. a minute ahead and 30 in. deep. The material was good quality Portland stone, and the rate was found to be exactly sixty times the speed of the reciprocating saws, fed with sand and water, at work in the same yard. With a softer stone the speed would, of course, be greater, and with a harder stone slower. It is stated from the yard, that since the day of our visit a smaller pulley has been placed at C, and the cut in Portland stone is now made at the rate of 4 in. per minute. The depth of cut is regulated by radius of saw blade. At a large slate quarry in America the rate of cutting is also said to be 4 in. a minute. This particular place appears to have been almost designed to show the capacity of this machine. The planes of cleavage lie horizontally, and not vertically as in Wales. The saw is set to work to cut a gate 200 feet or 300 feet in length; it is then moved sideways to cut another fissure, and so on until a considerable area is so treated. Next the rails are laid at right angles to the cut, and a second series of fissures is made, until the ground resembles a gigantic chessboard. It is then an easy matter to wedge off the rectangular blocks thus



CRUMP & BRERETON'S QUARRYING AND STONE DRESSING MACHINE.

formed, and prepare a fresh surface for the operations of the saw.

The machine shown in the photograph is evidently designed for quarrying, and not for stone dressing, but the mechanic will see that it would be easy to adapt it for the latter purpose. The cut surfaces from the present machine are not quite so smooth as those from the sand saw, but they have the advantage of being free from all cross-wind, and a few minutes on the rubbing table takes out all the circular marks of the saw teeth.

For a yard cutting machine, several plates would be mounted adjustably on one axis borne by a substantial frame. This frame would travel on a permanent tramway, say 6 feet gauge and 60 feet long, having a turntable for the machine at each end, and being supported by columns, at spaces of 10 feet, to a height of 5 feet above a series of cross tracks on which trolleys would carry the stone to be cut under the frame. The saw would run the whole length of the track, cutting the stones in succession as it went. As it passed, each trolley would be run out and reset, until the machine reached its turntable at the far end and was swung round for the return cut, when the stones would be in place ready for it, without loss of time.

In the number following the above, our contemporary published the following:

SIR: Having read with interest an account of Crump & Brereton's machine in your last week's impression, with your permission I should like to make a few remarks on the same. First, then, as to novelty; there is nothing new in it to me. It is now about twenty years since I went into this system of driving a steel disk, but abandoned the idea. After well considering everything, I came to the conclusion that the holes or teeth, as we may term them, in even a ½ in. plate, would not be durable, especially if working on a grit rock, nor can I conceive even now how they can stand any length of time. You also say that the tools only want grinding from once a day to once a month. I do not see how grinding is to be of any service; the clearance of the tools must wear away, and grinding can only make them worse. You give 2¾ in. per minute as the feed, and ultimately 4 in. in good Portland. Now, I regularly cut it as it comes at a speed of 6 in. per minute, and I have had four saws on one spindle cutting slate blocks at the same rate; and about eighteen years ago I had a saw at work in North Wales undercutting the vertical slate rock, and although this saw was only 3 feet 8 in. in diameter, I had it working 2 feet 4 in. deep. As described in the specifications of my patent, my first patent for movable teeth for circular saws was taken out in 1854, and my tool holders are fitted into the periphery of steel disks in the way you describe. I have made saws up to 13 feet in diameter capable of cutting through magnesian limestone at 3 in. a minute, and the attendant regularly changed his tools when the saws were going, so in this respect there is nothing new; but if the inventors get much encouragement from London builders, which I hope they will, there will then be something really new.

GEORGE HUNTER.

THE SPENCER SHOTGUN.

WE give the following as an example of the thorough and severe tests to which firearms are subjected when offered by interested parties for approval and adoption by the Government:

Report of Board convened at the National Armory, Springfield, Mass., pursuant to the following indorsement on letter from Chief of Ordnance directing test for strength and durability of a shotgun submitted by Mr. Lester A. Bartlett:

FIRST INDORSEMENT.

NATIONAL ARMORY, SPRINGFIELD, MASS., Jan. 6, 1886.

Respectfully referred to a Board to consist of Capt. W. S. Starring, Capt. Frank Heath, and Lieut. C. H. Clark, for test and report.

The shotgun will be tested by tests established for experimental rifles.

(Signed)
A. R. BUFFINGTON,
Lieut.-Col. of Ordnance, Commanding.

NATIONAL ARMORY, SPRINGFIELD, MASS., Jan. 11, 1886.

The Board met pursuant to the above indorsement at 10 A. M. Present—all the members. The arm submitted to the Board is known as the "Spencer Repeating Shotgun," having under the barrel a magazine which will contain five cartridges. Fig. 1 gives a full length representation of the gun. Figs. 2 and 3 are longitudinal sections, showing the breech mechanism.

This (Fig. 2) shows the parts of the gun in readiness for firing. The parts are as follows:

A, Frame.	B, Breech block.
C, Hammer.	D, Trigger.
E, Main spring.	F, Sear spring.
G, Firing pin.	H, Slide by which the gun is operated.

Fig. 3 shows the slide drawn back, the breech open, and a cartridge in the breech block, in position to be carried into the barrel. The hammer extends downward within the guard, enabling the firer to cock and uncock the gun, and showing also whether or not the gun is cocked. When the hammer is let down, it adjusts itself to the safety position. The backward movement of the slide, H, by the left hand opens the breech, throws out the exploded shell, and cocks the hammer. The forward motion puts a loaded cartridge into the barrel and closes the breech.

The Board received, through the agent of the gun, ammunition as follows: 200 rounds U. M. C. 2⅝ inch paper shells. An examination of five of these taken from different parts of the two boxes gave the following results:

Weight of Powder.—1, 104 grains; 2, 110·5 grains; 3, 106·5 grains; 4, 103 grains; 5, 103 grains.

5)527=Average, 105·4.

Each cartridge contained nine buckshot, the average weight of the five charges examined being 509·2 grains. A few metallic shell cartridges of the same make were also submitted, and during the tests there were fired 100 rounds of U. M. C. ammunition, paper shells, loaded with about 92 grains of powder and about 594 grains of No. 8 shot.

After examination of the gun and ammunition, the Board adjourned to meet at 10 A. M. the 14th inst.

NATIONAL ARMORY, SPRINGFIELD, MASS., Jan. 14, 1886.

The Board met pursuant to adjournment. Present—all the members.

FIG. 1.

The Board then proceeded to subject the gun to the following tests:

I. It was fired ten rounds by a representative of the gun, Mr. M. W. Bull.

II. The following defective shells were fired, the gun being in a fixed rest: 1. Paper shell, cross-sawed through head to near the top of metal cup. *Result.*—Slight escape of gas above and below the breech mechanism, but none toward the rear.

2. Metallic shell, cross-sawed entirely through the head. *Result.*—Increased escape of gas above breech mechanism, slight escape below, none toward the rear.

3 and 4. Metallic shells, filed through in four places about the rim. *Result.*—Considerable escape of gas above and below, setting paper on fire in one case. No escape of gas toward the rear.

5 and 6. Paper shells with four longitudinal cuts in each, the cuts being about 1⅛ inches in length and 1/16 in width. These commenced about 0·2" above the

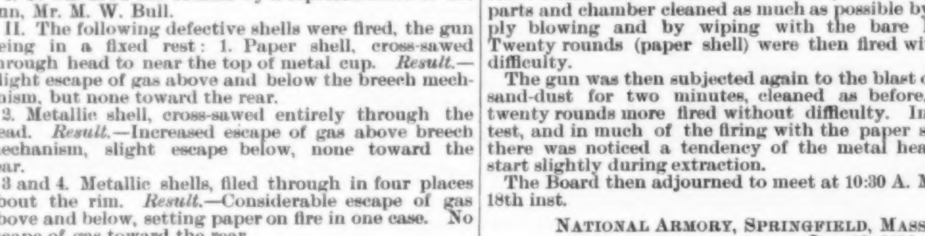


FIG. 2.

metal cup and extended to within about 0·5" of the top. *Result.*—No indication of escape of gas in either case.

III. The gun was next tested for firing rapidly at will, irrespective of aim, with the following results:

Firer, R. T. Hare, expert for the Board; time, 1 minute; rounds fired, 8; 2 thrown out, not fired, magazine loaded.

Firer, M. W. Bull, representative of gun; time, 1 minute; rounds fired, 22.

Firer, R. T. Hare; time, 1 minute; rounds fired, 12; 3 thrown out, not fired.

In this and in the following test, firing was begun with an empty chamber and magazine, the cartridges being disposed at will on the table.

IV. Test for rapidity with accuracy. The target was 6'×2', placed at a distance of 100':

Firer, R. T. Hare; time, 1 minute; rounds fired, 12; 1 thrown out, not fired, 3 remaining in magazine; hits, 57.

The Board then adjourned to meet at 2:30 P. M., on the 15th inst.

NATIONAL ARMORY, SPRINGFIELD, MASS., Jan. 15, 1886.

The Board met pursuant to adjournment. Present—all the members.

The test for *rapidity with accuracy* was continued.

Firer, M. W. Bull, representative of gun; time, 1 minute; rounds fired, 26; 4 remained in magazine; hits, 140.

V. Test was made of the rapidity of fire, irrespective of aim, the gun being used as a single loader, with the following results:

Firer, M. W. Bull, representative of gun; time, 1 minute; rounds fired, 18.

Firer, R. T. Hare; time, 1 minute; rounds fired, 11; 1 thrown out, not fired; 1 misfire, was exploded on second trial.

VI. Five rounds were fired to obtain the penetration at 100'. The butt was composed of pine boards, 1" in thickness, separated by about 1" open space. Most of the buckshot passed through two boards, and were found embedded to a depth of about their own diameter in the third board.

VII. *Dust.*—The piece was then exposed in a box, prepared for the purpose, to a blast of fine sand-dust for two minutes. It was then removed, and the breech parts and chamber cleaned as much as possible by simply blowing and by wiping with the bare hand. Twenty rounds (paper shell) were then fired without difficulty.

The gun was then subjected again to the blast of fine sand-dust for two minutes, cleaned as before, and twenty rounds more fired without difficulty. In this test, and in much of the firing with the paper shells, there was noticed a tendency of the metal heads to start slightly during extraction.

The Board then adjourned to meet at 10:30 A. M. the 18th inst.

NATIONAL ARMORY, SPRINGFIELD, MASS., Jan. 18, 1886.

The Board met pursuant to adjournment. Present—all the members.

The gun had, on the 16th inst., been subjected to the following: The breech mechanism and receiver having been cleaned from grease, and the chamber of the barrel greased and plugged, the butt of the gun was inserted to the height of the extractor in a strong solution of sal ammoniac, where it remained for *ten* minutes. It was then exposed for two days to the open air.

On the meeting of the Board, the gun was found, though well rusted, to be in a serviceable condition, and twenty rounds were fired from it without difficulty.

VIII. The gun was then placed in a fixed rest, and the following excessive charges fired:

1.	Paper shell,	120 gr. powder,	9 buckshot,	523 gr.	
2	" "	135 " "	9 "	506 "	
3	" "	135 " "	18 "	1,016 "	

The gun was cleaned and oiled during a recess of the Board, and at 2:30 P. M. subjected to the following tests:

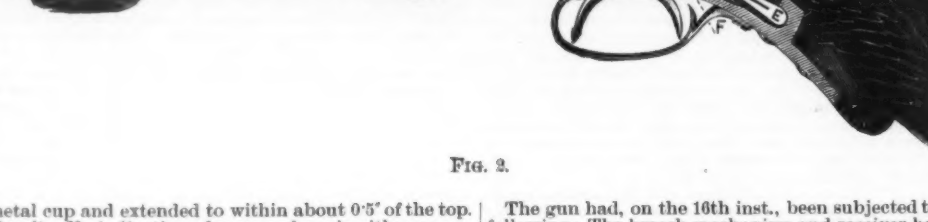


FIG. 3.

ILLUSTRATIONS OF THE SPENCER SHOTGUN.

IX. To test the endurance, together with *rapidity* and *accuracy*, the gun was fired by the members of the Board, the target being 6'×2' and placed at a distance of 100'.

The following were the **results**:

Rounds Fired.	Time.	Hits.
9	1' 4"	72 out of 81
9	1' 7"	73 " 81
12	1' 5"	65 " 108
9	1'	64 " 81
10	1'	74 " 90
13	1'	82 " 117
13	1' 58"	101 " 117
75		

The last thirteen fired were a combination shell known as the "Siebold pattern." Considerable difficulty was experienced in loading one of these, due to the fact of its having a double crimp at the head, which increased the thickness of the latter to such an extent that considerable force was necessary to get it into the recess far enough to allow the closing of the block. This shell is submitted with the report, marked A. Considerable difficulty was also experienced in the extraction of these shells, due to their expansion in firing.

X. Supplementary dust test.

The gun was fired with two defective cartridges, Nos. 1 and 2, and was then dusted as before for five minutes, the mechanism being in the mouth of the blow pipe and closed. The gun was then fired six shots, the last two being defective cartridges—one cross-sawed through the head and the other filed through at intervals around the rim. The shells used were paper, with the exception of the second defective one, which was of metal. The only trouble experienced was with one of the paper shells, the metal head of which had become loosened and drawn partially off on one side by the extractor. By using a knife blade on the metal head opposite the extractor, the shell was easily started out. The gun was then dusted for five minutes with the breech open, the mechanism being in the mouth of the blow pipe. Then, as in the first part of this test, the dust was removed from the breech mechanism and chamber as far as possible by blowing and by wiping with the bare hand.

Four shots (combination shell) were then fired. There was no trouble in loading and firing these shells, but the extraction was extremely difficult, due to the expansion of the shells and to the dust in the chamber.

The Board then adjourned to meet the 21st at 2 P. M.

NATIONAL ARMORY, SPRINGFIELD, MASS., Jan. 21, 1886.

The Board met pursuant to adjournment. Present—all the members.

XI. In the interval since the adjournment of the Board, the gun had been rusted as before, with the exception that the gun, after immersion in the sal ammoniac, had been placed in a warm room. This circumstance was more favorable to the rusting of the parts, and on firing, the mechanism remained perfectly day. In the previous test, when the gun was placed out of doors, some of the sal ammoniac solution had frozen in the recess of the breech mechanism, and on firing this was thawed out, and served to lubricate the parts.

On examination, the gun was found more thoroughly rusted than before, and it was with some difficulty that the breech block could be opened. As soon as the first sticking had been overcome, the gun was fired five rounds without any great difficulty. The breech could be opened and closed by the left hand alone, the gun being at the shoulder, but it required a quick motion and considerable effort. Occasionally there would be a "sticking," and it would then become necessary to place the muzzle on the floor, and use both hands to work it.

XII. *Excessive Charges.*—The following excessive charges were then fired, the gun being placed in a fixed rest. The powder charges were placed in paper shells, and in each case, after the insertion of the shell, the buckshot were loaded at the muzzle, and a single wad rammed down to hold the shot in position.

Powder Charge.	No. of Shot.	Weight of Shot.
1. 150 grs.	18	1,019 grs.
2. 150 "	18	1,004 "
3. 150 "	18	1,010 "
4. 150 "	18	1,020 "
5. 150 "	18	1,016 "

The Board then adjourned to meet at 2 P. M. on the 22d inst., the gun meanwhile to be allowed to stand without *cleaning* or *oiling*.

NATIONAL ARMORY, SPRINGFIELD, MASS., Jan. 22, 1886.

The Board met pursuant to adjournment. Present—all the members.

The Board then examined the gun for facility of working, and found it the same in that respect as during the firing of the 21st inst.

The Board then adjourned to meet at 10 A. M. the 23d inst.

NATIONAL ARMORY, SPRINGFIELD, MASS., Jan. 23, 1886.

The Board met pursuant to adjournment. Present—all the members.

Since the last meeting of the Board the gun had been thoroughly cleaned and oiled. It was then subjected to the following tests:

XIII. To determine the effect of a continued jolting on the cartridges in the magazine, the gun was placed in a wooden framework contrived to rise and fall about three inches, the number of shocks in a minute being about eighty. The metallic cartridges were first subjected to this action for fifteen minutes. When removed from the magazine, the cartridges did not show any injury of consequence, and they were afterward fired without difficulty.

The paper cartridges were subjected to this test for twenty minutes, after which the five charges were fired without interruption. The paper cartridges used in this test were specially prepared as a waterproof cartridge by the U. S. Cartridge Co.

Five of these waterproof cartridges were tested by placing in a basin of water, being completely submerged. Three were removed after soaking over twenty-two hours. One of them was opened, and the powder found to be in a serviceable condition. Two were then dried for about eighteen hours, when they were fired, the loading being somewhat difficult. Two remained in the basin over forty hours, were then dried a few minutes on a heater, and one was fired after considerable difficulty in loading. The other it was found impossible to load.

XIV.—*Tests for Rapidity without Accuracy.*

Firer, M. W. Bull; circumstances, magazine and chamber loaded; time, 3½ sec.; rounds, 5—one cartridge thrown out, not fired.

Firer, M. W. Bull; circumstances, magazine and chamber loaded; time, 4⅛ sec.; rounds, 5—one cartridge thrown out, not fired.

Firer, M. W. Bull; circumstances, magazine and chamber loaded; time, 2⅝ sec.; rounds, 6.

Firer, C. M. Spencer (inventor of gun); circumstances, magazine and chamber loaded; time, 4¼ sec.; rounds, 5—one cartridge thrown out, not fired.

Firer, M. W. Bull; circumstances, magazine and chamber loaded; time, 46 sec.; rounds, 26—one cartridge thrown out, but afterward loaded and fired.

Firer, R. T. Hare; circumstances, magazine and chamber loaded; time, 1 m. 9⅝ sec.; rounds, 26—two misfires. Both had the indentation from the firing pin in the primer, and one exploded on second trial; the other could not be fired.

The Board then adjourned subject to the call of the President.

NATIONAL ARMORY, SPRINGFIELD, MASS., Jan. 26, 1886.

The Board met at 2 P. M., pursuant to the call of the President. Present—all the members. The Board then proceeded to test the gun for penetration, as follows:

XV.—100 yds. The target was composed of two 1" pine targets, separated by 1" clear space. At this range the greater portion of the buckshot striking the target penetrated the first thickness, and were found either embedded in the second or fallen between the two, after having made deep indentations in the second board.

At 125 yards the penetration was in most cases just through the first boards.

SUMMARY.

In all the tests, over 378 rounds have been fired from the gun. Of these, *ten* were with defective shells, and *eight* with excessive charges, varying from 120 to 150 grains of powder, with, in several cases, double charges of buckshot.

The gun remains in excellent condition, as far as its serviceable qualities are concerned, none of the parts being injured or out of order. It has passed very well the various tests to which the Board has subjected it, and the Board is of the opinion that the strength and endurance of the gun are entirely satisfactory.

In the firing by the expert of the Board, Mr. R. T. Hare, *seven* cartridges were thrown out unexploded, *six* in firing rapidly at will, and *one* in firing for rapidity with accuracy. In the rapid firing by the expert representatives of the gun, *three* unexploded cartridges were thrown out. This does not include those thrown out because of defective primers, but those cases where the cartridges were not fired because of premature pulling on the trigger before the primers were in position to be struck by the firing pin. In the firing by the members of the Board, but little difficulty of this kind was experienced.

With reference to the *ammunition* used, the Board found the waterproof paper cartridge (U. S. C. Co., Lowell, No. 12) to work better than the other varieties. These gave no trouble whatever in loading or extracting. There were, however, in the one hundred rounds of this cartridge fired, two or three defective primers.

The only difficulty experienced with the other paper shells (U. M. C. Co., No. 12, samples BB) was the starting of the head in extracting. But few of the metallic shells (U. M. C. Co., No. 12 A) were used. With these there was noticed a slight tendency to "stick" in extracting.

With the combination shells (U. M. C. Co., No. 12, Siebold's patent) there was great difficulty in extracting in some cases, and with all it required more effort to extract than in the case of the paper shells.

W. S. STARRING, *Capt. of Ordnance.*
FRANK HEATH, *Capt. of Ordnance.*
CHARLES H. CLARK, *Lieut. of Ordnance.*

EARLY LOCOMOTIVES.

THE "John Bull" engine, the locomotive brought to this country from England in 1831, and remarkable from the fact that it was in actual continuous service for over 30 years, has been placed on exhibition in the main hall of the National Museum at Washington. This venerable and curious-looking locomotive half a century ago pulled a train of two or three cars or coaches, looking like old fashioned stage coaches mounted on car wheels, and was considered a wonder of modern science and mechanical skill. It is intended to form a part of a collection in the museum, which will tell the story of the development of steam as a motive power in transportation.

Mr. J. Elfreth Watkins, who is in charge of this department, has just left for Europe in search of drawings, models, etc., which will render this department of the museum more complete. In a recent interview Mr. Watkins states:

"Among the earliest railroads in this country was a road from Quincy granite quarries, Massachusetts, to the Neponset River, a distance of several miles. The road was built of strips of granite put on the ground as you build a curbstone, and upon these granite rails ran cars with flanges on the wheels to carry the granite to the wharf. There was another road built very early at Mauch Chunk, Pennsylvania. It was laid with transverse cross ties of logs unhewn, but notched to receive roughly hewn longitudinal rails of wood. Upon these rails were run cars used to take coal from the mine to a coal wharf on the Lehigh River. The Baltimore & Ohio was a very early railroad. Twelve miles of railroad, from the city of Baltimore to Ellicott's Mills, was perhaps the first piece of railroad regularly operated in this country. Its construction was begun in 1828. It is hoped we will be able to obtain from this company one of their old grasshopper engines, which was shown at the Chicago railroad exhibition. The first 100 miles of railroad built and operated in this country was in South Carolina, and upon that road the first three American-built locomotives were used; the first about 1830. An engraving from the original drawings of each of these locomotives will be exhibited in my section.

"The Camden & Amboy Railroad, which was destined to be the great highway of travel between New York and Philadelphia, ordered the engine 'John Bull,' which is on exhibition here now, through its President, Robert L. Stevens, who was sent to Europe for the purpose in the fall of 1830. The engine was built by Robert Stephenson & Co., Newcastle-on-Tyne, was shipped in May and arrived at Bordentown, N. J., the last week in August, 1831. It was put together and run for the first time early in September, 1831. It is a rather interesting fact to note that the man who put it together and first ran it, Isaac Dripps, was the same who placed the rudder after the propeller. This engine, when it arrived in the country, was substantially as it now is—with inside cylinders, four driving wheels, and multitubular boiler. The driving wheels originally had cast-iron hubs and locust spokes and fellies and a tire about 5 in. wide and flanged, shrunk on like the tire of an ordinary cart-wheel. There was no headlight, no bell, and no pilot. The steam-pipes were inside the boiler and the dome was right over the fire box. In the dome was a lock up safety-valve, which the engineer could not reach. There was no cab, and no tender came with the engine. To take its place when the first experiments were made, a tender was made of an ordinary construction car, with a whisky barrel to hold the water, which was fed to the engine through hose made by a shoemaker out of leather, connected with the tank by waxed thread.

"When this engine arrived in this country, it was the most perfect locomotive in the world. It had been built by George Stephenson's firm as an improvement on the 'Planet,' which, built in 1830, was the first engine which had the combination of horizontal cylinders, multitubular boiler, and the blast pipe. The 'John Bull' was the first engine running in this country which possessed these three essential features of a locomotive, for lack of which earlier engines in both countries were comparative failures.

"The 'John Bull' was first used to demonstrate to the legislature of New Jersey, which had been asked to charter a steam railroad, that the use of steam on railroads was to be the thing of the future. It was tried before the legislature of the State, November, 1831, and was so successful that the legislature granted to the Camden & Amboy the privileges that they asked.

"After a trial, made on a short piece of track then constructed, the engine was stored in a shed to await the completion of the balance of the track. At that time a man named Peale, who had a large museum in Philadelphia, became anxious to have a toy engine built to run on a circular track in his museum. He arranged with Baldwin, a mathematical instrument maker and a man of ingenuity, who went to Bordentown, where the engine was stored, and, in connection with Isaac Dripps, made an examination of her. He then built a toy locomotive, which was exhibited as a curiosity for a number of months. The managers of the Philadelphia, Germantown & Norristown Railroad saw this toy locomotive, and ordered a locomotive of regular size from Baldwin. It was built in 1832 and called 'Old Ironsides.' With its construction began the history of the Baldwin Locomotive Works, the largest of their kind in the world. A number of others went into the business, but the Camden & Amboy Railroad was for a number of years looked upon as being the pioneer in locomotive construction in and about Philadelphia and New York, although the Baltimore & Ohio Co., in the construction of the grasshopper, brought out a type which was commercially successful for the peculiar requirements of the business which the road entered upon, and their invention should not be overlooked.

"I will be able to show a drawing of the first locomotive that ever performed work continuously in the world," said Mr. Watkins. "It was built by Trevithick and was run on the Merthyr Tydvil railroad in Wales as early as 1804, and was used to haul pig iron from a furnace to a wharf. Trevithick was an advocate of high pressure, and his engine apparently had smooth tires, horizontal cylinders, driving spur gearing, and a return flue boiler, the fire being in an internal chamber and urged by the exhaust escaping up the chimney.

"When Robert L. Stevens was on the ship on his way to Europe to order the 'John Bull,' in 1830, he devoted a considerable amount of time to whittling out cross-sections of what he thought would be a good kind of iron rails to lay on the railroad. The best rail then known was the T rail without any base. This style had been adopted by all the most important roads in Europe. Owing to its peculiar shape, it required a chair on every cross-tie or stone block, as the case might be. Stevens was the first man to design the rail which he termed the 'H' rail—in other words, a rail with a base which could be spiked with 'hooked-headed' spikes directly to the bearing. Under the 'John Bull' engine are two of the original rails rolled from the first design of Robert L. Stevens in 1830. When the exhibit is complete, the rails will rest on the original stone blocks made at Sing Sing, New York, for this road, and we will use a spike similar to the original 'hooked-head' to join the rails to the wooden pins in the holes in the stone blocks. Those rails have iron tongues, the rudimentary splice-plates of the present day. They were attached to the rails by rivets put on hot. Thus we see that as early as 1830 there was in use on the Camden & Amboy Railroad tracks substantially what is now the American railroad splice bar and railroad spike. These have been improved in shape and made stronger to meet the requirements of an increased amount of traffic, but the ideas approved now, after a lapse of 55 years, are substantially the same. The wooden cross-ties have taken the place of the stone blocks, which, owing to expense and rigidity, had to be abandoned a few years after they were first laid.—*Washington Evening Star.*

THE FORESTRY EXHIBIT AT BUDAPEST.

The Forestry Pavilion.—Among the pavilions that gave an original character to the Budapest Exhibition was the one devoted to forestry. This structure was characteristic. Enormous trunks of trees and piles of wood and planks, covering the ground, gave the visitor some idea of the forest wealth of Hungary. We shall briefly sum up the principal points of this interesting exhibit.

Superficies of the Forests.—According to the most recent statistics, the total territory of Hungary covered by forests is 22,919,288 acres, 19,106,600 of which are situated in Hungary proper, and 3,812,688 in Croatia. Of the total forest area, 67% belongs to the State, and produces, on an average, 9,884,000,000 cubic feet of wood per annum, while 33% belongs to companies or individuals.

Objects Exhibited.—Among the principal objects exhibited were timber and building wood of very beautiful aspect, ties, boards and laths, wood for wheelwrights

FIG. 1.—FORESTRY PAVILION AT THE BUDAPEST EXHIBITION.

and match-makers, and staves and wheels of various forms. One interesting part to study was that of ornamental objects of punk, household utensils, and agricultural instruments made of various foreign woods.

The flooring industry was well represented, and some very beautiful specimens were met with in the private pavilions of Messrs. E. and M. Neuschloss and Gregersen. As a secondary product of the exploitation of forests, charcoal occupies the first rank. Up to the present, but little attention has been paid to the recovery of such secondary products as resin, pitch, turpentine, and acetic acid.

Mode of Felling and Floating Wood.—As regards cutting timber, the state and large land owners select for this only such trees as are from 80 to 120 years old. Oak forests are allowed to stand for from 120 to 160 years, with a view of obtaining trees of as large a diameter as possible. The state forestry administration employs artificial reboisement only. It has been endeavoring since 1880 to get land owners to do the same, and with this object in view has, during the last three years, delivered gratis to private individuals more than eleven million young plants derived from its nurseries.

Trees standing upon elevations, and designed for carbonization, are cut into logs that run in slides, partly high and dry, and partly in water, to the bed of the river, where they are collected together. An up-stream sluice permits of letting out the water contained in a pond, and this water carries along the wood, the lost portions of which are gathered up afterward. The wood is floated in some cases to a distance of over twenty-four miles.

Near the charcoal works, high wooden gratings (Fig.

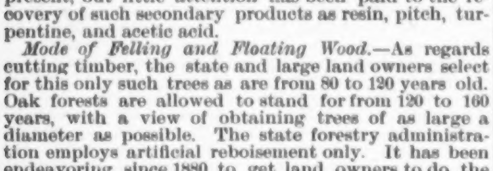


FIG. 2.—BOOMS FOR ARRESTING LOGS.

2) arrest the logs, and the latter enter side canals, from whence they are taken and piled up till dry, after which they are put into the kilns. These latter, where the establishment is large, are 52½ ft. in diameter, and contain 5,650 cubic feet of wood, while those established in the forest are only about 33 ft. in diameter. The product is usually about a third of a bushel per cubic foot.

Principal Forest Districts.—Without taking account of the forest districts under control of the state, we may mention among the largest ones owned by private individuals those of the domain of Arva, of Count Andrassy, of Kiss Nicolas de Nemesker, of Malaczka, and of Munkacs. Besides these vast private domains, two industrial societies possess forests which they work directly for the needs of their factories.

Special Pavilions of the Forestry Section.—In addition to the central forestry pavilion, we may cite that of Haas, of Budapest. This house in 1881 founded a tannin factory at Lipto-Ujvar, which annually consumes from 26 to 38 million pounds of pine and oak bark, and manufactures from 5½ to 6 million pounds of tannin, chiefly designed for export, without counting 141,288,000 cubic feet of timber and building wood sent to the Danubian provinces in Roumania and Bulgaria.

The pavilions of Gregersen and of Neuschloss alone formed two striking objects. The last-named represented a transportable guard-house, of picturesque style, whose partitions and floors were formed of inlaid woods of the most varied colors.

Hunting and Fishing.—The administration of forests does not confine itself to the simple exploitation of the woods, but treats pisciculture and hunting with equal care. The collection of stuffed animals in the grand pavilion, comprising black and brown bears, wolves, foxes, stags with enormous antlers, and the most diverse birds, the whole grouped in an attractive manner, greatly interested our French sportsmen, who are but slightly or not at all accustomed to such exhibits.

Let us add that the forestry pavilion was purchased by a Hungarian land owner, who designs to ornament his forests with it, and who paid $17,000 for it.—*Le Genie Civil.*

NEW YORK PUBLIC WORKS.

THE annual report of the Department of Public Works for the year ending December 31, 1885, contains the following items of interest:

"The expenditures for 1885 were as follows:

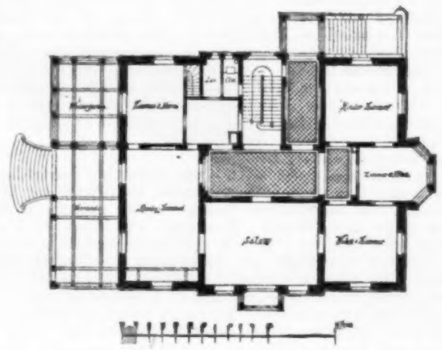
From annual appropriations, including liabilities	$2,399,409 17
From local improvement fund....	885,480 49
From funded debt—for water supply..........................	444,519 79
From special funds created by collections for water meters and permits for steeet openings.....	61,878 65
Total...........................	$3,791,288 10

"This is $852,253.19 less than the expenditures for 1884, and $933,855.80 less than those for 1883.

"The average rainfall in the Croton watershed for 1885 was 44·69 inches. During 127 days 5,720 million gallons of water were drawn from the storage reservoirs and lakes to make up the deficiency in the natural flow of the Croton River. For the Bronx River supply, 1,425,000,000 gallons were drawn from the Rye Ponds Reservoir and the Kensico Reservoir to make up the deficiency in the flow of the river. Of the $3,137,791 expended since 1879 for works, lands, etc., for the supply from the Bronx and the Byram rivers, over $1,100,000 is chargeable to the object of getting the water of the Byram River, but the city has not yet acquired the necessary water rights to take the water, and will derive no benefit from the expenditure until these rights are acquired.

"In extending the water service to the new streets, 17·02 miles of water pipes were laid, making the total length of pipes at the close of the year 579·93 miles. About twenty-six miles of water pipes along the water front are so corroded by contact with salt water that large breaks are liable to occur at any moment, and immense quantities of water are now lost through leakage from these pipes. There are now 13,680 water meters in use, of which 2,065 were placed last year. The returns of water supplied through meters in 1885 are 22,177,700 gallons.

"The sewerage system on Manhattan Island now includes 310·36 miles of sewers, with 5,035 receiving basins, of which 18,663 feet of sewers and 28 basins were built last year. The constitutional amendment adopted in 1884, limiting the city debt, has stopped all local improvements payable by assessments, except completion of all contracts. The Common Council has passed ordinances for paving twenty new streets and for grading thirty-two new streets, and sewers are required in sixty-nine streets. These improvements cannot be made until relief is obtained from the amendment, and, meantime, vacant lots will not be built



THE SCHWABE VILLA.—PLAN.

upon and the houses already built will not be available for occupation.

"There are now 23,555 gas lamps, 708 electric lights, and 50 naphtha lamps in use on the streets, parks, bridges, and docks of the city, and 977⅝ miles of gas mains under the streets.

"The amount of revenue from the water service for 1885 was $2,134,675.83; the increase over the previous year, $147,276.01; uncollected water rents returned in arrears, $164,689.55; total revenue from the water service, $2,200,265.38."

THE SCHWABE VILLA, LEIPSIC.

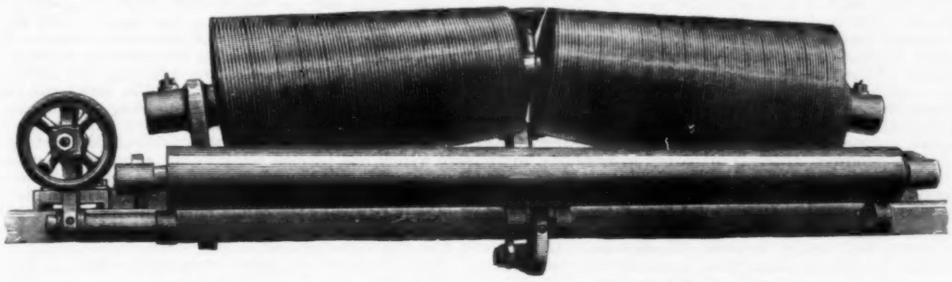
OUR engraving shows an elevation of a villa in Leipsic, designed by W. Grimm, architect. It is of masonry, two stories, with Mansard roof and towered bay windows, brownstone trimmings. Substantially built, elegantly finished. Total cost, $36,000.

A VILLA IN REUDNITZ.—THE SCHWABE VILLA, LEIPSIC.—W. GRIMM, ARCHITECT.

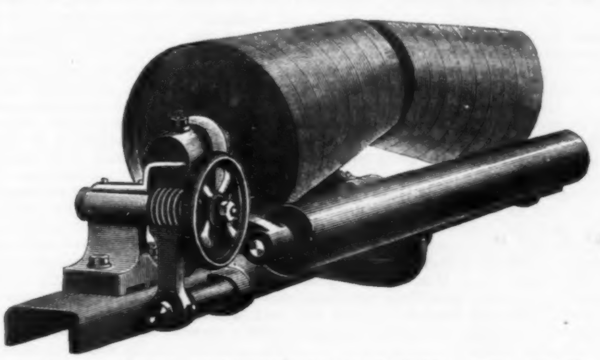
CLOTH STRETCHING MACHINE.

BY W. Birch & Company, Milton Street, Manchester.—With a simple diagonal plate it frequently happens that creases in the cloth entering a mangle are not eliminated, and the result is damage to the cloth. The sectional stretcher, again, is rather cumbersome and heavy, though fairly efficient in action.

To avoid the defects of both these, Messrs. Birch have introduced the novel form we herewith illustrate, and which consists of two conical compound fluted rollers placed in a frame, with their smaller diameters together. Each roll is built up of a number of narrow disks threaded upon a central spindle, each disk being correctly turned to gauge, so as to form a portion of the conical surface. The flutings in the disk are circumferential, and of a form that insures a good grip upon the cloth, the perpendicular edges of the grooves being outward, and the raised flutes or ribbings being of a wedge form, with backs sloping toward the narrow end of the rolls. At the larger ends the central spindle of each roll is carried in a swiveling bearing, free to accommodate itself to any movement of the roll, while at the narrow or inside ends the bearings are of the ball or bicycle type, one fixing carrying the two rolls, and this fixing is movable by means of a worm and wheel, as shown in our engraving. By this means the cone ends may approach to or recede from the front of the machine, and when in a stretching position the sides of the cones toward the direction in which the cloth is coming form an entering angle, and the flutings of the rolls thus diverge upon the separate cones, and this it is which gives the stretching action. By means of the worm and wheel the angle between the cone faces is variable, and when those faces form one straight line no stretching action takes place, and when the angle is reversed, and becomes salient, the reverse action would be obtained. By a simple turn of the handle the degree of stretch can be modified without stopping the machine or requiring the attendant to remove his eyes from the running cloth—an important matter especially in a water mangle. The stretching cones are carried on a suitable frame or loose wheel, which can readily be attached to the front of the mangle in the usual position. Should lint or dirt penetrate between the separate disks, provision is made for its extraction at the ends of the cones, the disks being cast with arms, and not solid, as plates.—*Textile Manufacturer.*



BIRCH'S CLOTH STRETCHING MACHINE.—FRONT VIEW.



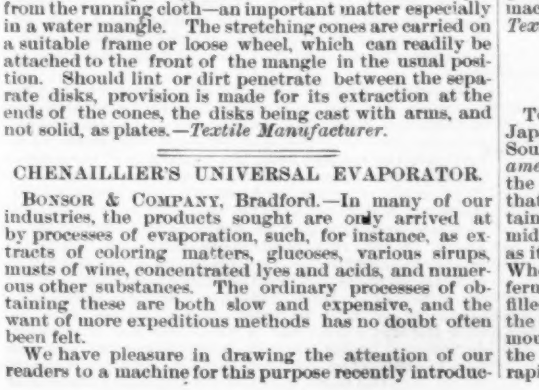
BIRCH'S CLOTH STRETCHING MACHINE.—END VIEW.

CHENAILLIER'S UNIVERSAL EVAPORATOR.

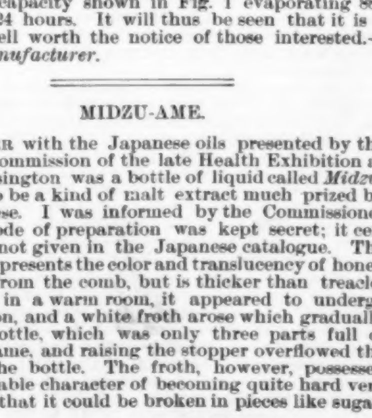
BONSOR & COMPANY, Bradford.—In many of our industries, the products sought are only arrived at by processes of evaporation, such, for instance, as extracts of coloring matters, glucoses, various sirups, musts of wine, concentrated lyes and acids, and numerous other substances. The ordinary processes of obtaining these are both slow and expensive, and the want of more expeditious methods has no doubt often been felt.

We have pleasure in drawing the attention of our readers to a machine for this purpose recently introduced into this country from France. The accompanying illustrations show the construction of the machine. As will be seen, it consists of a frame carrying a cistern to contain the liquids that are to be treated. A pipe shaft furnished at each extremity with stuffing boxes or steam glands carries a series of double convex steam chambers, which, it will be seen, give a large evaporating surface. The method of driving the machine is shown. When steam is admitted and the machine started, a series of ladles or small buckets, the form of which may be varied according to requirement, dip into the liquid contained in the cistern, and, carrying it up, pour it in a thin layer over both sides of the double convex steam chambers. These ladles are not attached closely to the chambers, but at the bottom a line aperture is left, so that when the ladle is lifted from the liquid it immediately commences the distribution of its contents over the faces of the chamber; that which is not delivered in this manner being discharged from the top. It will thus be seen that the evaporating surfaces are utilized to the fullest extent. Of course, it will be obvious that the portions of the chambers which are continuously in succession immersed in the cistern are doing efficient service at the same time. The contents of the cistern can speedily be raised to the boiling point, and the evaporation then proceeds rapidly. The water resulting from the condensation of the steam employed is discharged at one end through the pipe shown in Fig. 1. Where it is not desired or agreeable to work the machine open, a cover can be adopted, as seen in the section, and the vapor discharged outside the building. Evaporation can be conducted at a temperature as low as 70°, and at a very high one when required.

These machines are made in all required sizes, and of various types, in metal suitable for their requirement, as iron, lead-soldered lead, and copper, according to the different branches of industry in which they are intended to be used. Their capabilities are very great, one of the capacity shown in Fig. 1 evaporating 880 gallons in 24 hours. It will thus be seen that it is a machine well worth the notice of those interested.—*Textile Manufacturer.*



CHENAILLIER'S UNIVERSAL EVAPORATOR.



SECTION, WITH COVER.

MIDZU-AME.

TOGETHER with the Japanese oils presented by the Japanese Commission of the late Health Exhibition at South Kensington was a bottle of liquid called *Midzu-ame*, said to be a kind of malt extract much prized by the Japanese. I was informed by the Commissioner that the mode of preparation was kept secret; it certainly was not given in the Japanese catalogue. The midzu-ame presents the color and translucency of honey as it flows from the comb, but is thicker than treacle. When kept in a warm room, it appeared to undergo fermentation, and a white froth arose which gradually filled the bottle, which was only three parts full of the midzu-ame, and raising the stopper overflowed the mouth of the bottle. The froth, however, possessed the remarkable character of becoming quite hard very rapidly, so that it could be broken in pieces like sugar. As the autumn approached and the weather became colder, the fermentation entirely ceased.

A paper has recently been published in the Transactions of the Sei I Kwai, or Society for the Advancement of Medical Knowledge in Japan, which throws some light upon the uses and mode of manufacture of this curious preparation. In the number for November, 1885, p. 131, Dr. J. C. Berry, of Akayama, says concerning the midzu-ame that until recently it was used in Southwestern Japan only as an article of diet for babies, weakly children, and old people, but that now it is largely taken by those who have been brought in contact with or instructed by foreign physicians. Dr. Berry adds that he has used it considerably during the last five years, more especially in cases where food medicines were required. He has also prescribed it, properly diluted, with dialyzed iron and cod liver oil. The only advantage it possesses over maltine lies, he believes, in its more easy digestibility.

The method of manufacture of midzu-ame is as follows:

1st. Malt (moyashi). This is made by putting barley into a pail with a perforated bottom, moistening it for two weeks with water, during which time the barley germinates, sooner or later, according to the weather. It is then spread out to dry, the sprouts are rubbed off and winnowed away, and the malt is ground, when it is ready for use.

2d. One *to* (1,097 cubic inches) of *mochi-gome*, the very glutinous rice used to make *mochi*, is cooked by steaming it in a wooden box till soft. It is then emptied into a pail and 450 *momme** (about 3¾ lb.) of malt is added with 5 *sho* (equal to half a *to*) of water. The whole is then thoroughly mixed with the hands, the rice being squeezed and crushed till it assumes a hard, jelly-like consistence. It is then allowed to remain for twelve hours, during which time it is stirred thrice. During this stage of the process it is covered with straw mats if the weather be very cold, or kept in a cool place if the weather be warm. It is then removed and placed in hempen bags, put into a strong box, and the liquid expressed by firm pressure. Lastly it is evaporated to a proper consistence over a slow fire.

The taste of midzu-ame is slightly sweet and by no means unpleasant.

OIL OF PERILLA OCYMOIDES.

THIS oil, although not so rapidly siccative as the Japan wood oil,† is extensively used in Japan as a drying oil. It is obtained by pressure from the seeds, 100 parts by weight yielding about 40 of oil. The seeds are grayish brown and about the size of millet seed. The oil is used to waterproof clothing and the paper used for parasols, and a kind of paper leather is also made with it, which is strong, supple, solid and impermeable. It is often added to the crushed berries of the wax tree (*Rhus vernicifera*) to render the extraction of the wax (by pressure) more easy and rapid. Insects are said not to attack materials prepared with this oil. The oil is also used mixed with lacquer to give a brilliant coating of transparent varnish, which slowly becomes yellow, and does not need polishing, and which permits the natural grain of the wood to be seen. It can also be used for varnishing colored drawings without changing the shades of color.‡ The plant, which is called Ye-goma in Japan, belongs to the natural order Labiatæ. It is very common in many provinces of the isles of Nippon and Kiusiu, growing in shady places by the sides of roads, upon the mountains, and in waste places. It is also much cultivated. It flowers in October. It is figured in the *So mokou Zoussetz*, vol. xi., No. 25, and described on p. 105.—*Pharm. Jour.*

EMULSION MAKING FOR AMATEUR PHOTOGRAPHERS.

THIS being the season when amateur photographers are perforce debarred from outdoor work, I have thought that a few remarks on the above subject would not be unacceptable. I therefore subjoin a brief account of a method of proceeding which will, I believe, be found to result in all respects satisfactorily.

The formula which I have found to prove most useful, though only slightly modified from others published, is as follows:

For ten-ounce emulsion take—

Potassium bromide	50 grains.
Ammonium bromide	110 "
Nelson's No. 1 gelatine	20 "
Water	7 ounces.

Place a jar containing this in a vessel of cold water and raise the water to boiling point, when *immediately* remove the jar. Have ready weighed out—

Silver nitrate	200 grains in crystals.
Potassium iodide	6 grains.

Dissolved in half a drachm of water.

In the dark room add the nitrate of silver to the bromized gelatine, and proceed to beat up vigorously for about five minutes with a horn or silver fork, then pour in the solution of iodide, and again beat up for some time.

Now proceed to acidify with hydrochloric acid, and test with litmus paper till there is an acid reaction, the paper turning clearly red. No definite quantity of the acid can be prescribed, as I have found that in some cases I have been obliged to add as much as eight drops of strong acid to get rid of alkalinity, while in others one or two drops effected the purpose. I am convinced that a large proportion of failures in emulsion making arise at this point, as I have never failed in making a clean working emulsion giving clear shadows after attending carefully to this matter. Next replace the now sensitized emulsion in its jar, in the vessel of boiling water, there to remain boiling for one hour, or longer if greater sensitiveness be required.

In the meanwhile weigh out—

Nelson's No. 1 gelatine	60 grains.
Heinrich's gelatine	120 "

And, in a second jar, soak this for about three-quarters of an hour in cold water, as much as the jar will hold;

* 120 momme = 1 lb. avoirdupois.

† *Pharm. Jour.* [3], xv., p. 637.

‡ *Bull. Soc. Acclimatization*, May, 1882, p. 291.

then reverse the jar, with a piece of muslin over the top, and drain thoroughly.

When the emulsion has boiled for the specified time, remove it from the boiling water, and replace it by the jar containing the soaked gelatine. Plunge the jar of emulsion into cold water, and keep it there until the gelatine in the second jar is thoroughly liquefied. The vessel of boiling water having been removed from the fire before the jar of gelatine was placed in it, the temperature of both will now be found to be just suitable for mixing.

This must of course be done in the dark room, pouring the emulsion into the gelatine so as to leave behind any coarse precipitate which may have been formed. The process of thorough mixing for some minutes must now be repeated, and the emulsion finished by adding about a drachm of strong ammonia, with constant stirring, when it may be put aside to cool and ripen for a few days.

The washing and remelting may be done, as most convenient, by any usual method. I may mention that in some cases complete precipitation of the gelatino-bromide has taken place when cooling, in the vessel of cold water, after boiling; but as this is not of uniform occurrence, I depend upon the method of washing the finished emulsion. The vessels I employ are ordinary two pound jars, such as are used for Moir's marmalade. When boiling, I close them with a bung in which a groove has been cut, and cover with a tin cap—such as the lid of a canister—to exclude any ray of light, as I do not boil in the dark room. For storing nothing is better than a stone ink bottle—of course, thoroughly cleansed—and in this the emulsion is remelted for coating, over an ordinary fire, as in boiling.

The idea of employing the two bromides occurred to me on account of having observed that with potassium I got clear shadows, with, possibly, too little detail in them, while the reverse was apt to be the case when ammonium had been employed, and I think the mixture will be found an improvement.—*Thomas Earp, in Br. Jour. of Photo.*

MAGNETISM OF SHIPS AND THE MARINER'S COMPASS.*

By WILLIAM BOTTOMLEY.

TWENTY years ago the writer of an article on the "Mariner's Compass" remarked:

"There are some subjects which seem to be doomed to general neglect, almost on account of their peculiar claims to universal attention. A seafaring people might be supposed, as a matter of course, to take a deeper interest in the theory of the mariner's compass than in almost any other branch of science, and yet it is scarcely too much to say that the investigations which have revolutionized this department of magnetical science have awakened no interest in the general public, and have scarcely been mastered by more than a few of those whose lives are hourly risked upon the supposed accuracy of the compass indications."

The same remark might with almost equal truth be made at the present day. Perhaps one of the principal reasons why so little interest is taken in this subject, and why the effect of the magnetism of the iron of a ship on the mariner's compass is so little understood by the majority of sailors, is because the books and papers which have been written on the subject are put in too mathematical a form to be intelligible to ordinary readers.

I have been asked by the Council of this Society to give you this evening an account of the magnetism of an iron ship, and the means which are adopted for counteracting its effect on the mariner's compass.

The subject of the magnetism of a ship is one of considerable complexity, and to understand it completely requires a certain amount of mathematical knowledge. It would be impossible, in the course of a single paper, to give any detailed explanation of the theory of an iron ship's magnetism. I shall, therefore, confine myself to giving a general idea of those magnetic forces which are found to exist in an iron ship, and which combine to produce the errors of the compass, so troublesome and dangerous to the navigator.

Before entering on the subject, it may be desirable to give some brief explanation of those fundamental principles of magnetism which are intimately connected with the mariner's compass.

Magnetism may be defined as the power which certain bodies called magnets possess of attracting iron. There are two kinds of magnets—natural and artificial. Natural magnets are found as an ore of iron called loadstone; artificial magnets are made of bars of tempered steel, and are magnetized by the action of other magnets, or by a current of electricity. If a straight bar magnet be examined, it will be found that the magnetism in it is not uniformly distributed along the length of the magnet, but that the attractive force is most powerful near each end and diminishes toward the center.

If a magnet be hung by a fine thread round the middle of the bar, or suspended on a point, so as to be free to turn round a vertical axis, it will be found to take up a fixed direction—one end of the magnet will point toward the north and the other end toward the south. Now, if another magnet be brought near this suspended magnet, it will be found that the pole of the latter pointing toward the north will be attracted by one end of the second magnet, and repelled by the other end. Similarly, the end of the suspended magnet pointing toward the south will be attracted by one end of the second magnet, and repelled by the other. But the pole of the second magnet which attracts the north-pointing end of the suspended magnet will repel the south-pointing end, and the pole which repels the north-pointing end will attract the south-pointing end.

Now, if I suspend this second magnet similarly to the first, you will see that the end which attracted the north-pointing end will turn toward the south, and the end which attracted the south-pointing end will turn toward the north. We thus learn that there is a difference in the magnetism of the two ends of a magnet, and, further, that similar poles repel one another, and opposite poles attract one another.

The fact—which constitutes the essence of the mariner's compass—that a suspended magnetic needle takes up a definite position has been known for a very long time. It is said to have been used by the Chinese as a guide for traveling by land somewhere about 2400 B. C. Whatever may be the exact time of its becoming known in China, it seems to be certain that it was a long time after that—probably several thousand years—before it became known in Europe. Indeed, the introduction of the mariner's compass into Europe has not been traced to an earlier date than the end of the eleventh century.

The true explanation of this wonderful phenomenon, of the tendency of a suspended magnet to turn to a definite direction, was first given in the year 1600, by Dr. Gilbert, physician in ordinary to Queen Elizabeth, in his famous work on "The Magnet, and the Earth a Great Magnet." He explained that the earth acts on a movable magnet in the same way that another magnet does; in fact, that the earth may be considered as a large magnet having one of its poles situated somewhere near the north pole of the earth, and the other near the south pole of the earth. One end of a movable magnet points toward the north because it is attracted by one of the magnetic poles of the earth, and the other end points toward the south because it is attracted by the other magnetic pole of the earth.

Now, I have shown you already that similar poles repel, and dissimilar poles attract. Therefore the magnetism of the pole of this magnet which is attracted by the north magnetic pole of the earth must be dissimilar to the magnetism of the northern portions of the earth, and similar to the magnetism of the southern regions. The end of the needle which is repelled from the north, and attracted to the south, must have magnetism similar to the earth's northern regions. Thus the end of the needle which points *from* the north has true northern polarity, and the end which points *toward* the north has true southern polarity. Gilbert pointed this out, and protested against the practice of writers, instrument makers, and sailors speaking of the end of a magnet which is attracted toward the north as the north pole of the magnet. Unfortunately, this mistake has been persisted in to the present day. We still find instrument makers marking with an N the end of the magnet which is attracted by the north pole of the earth, and many writers of books, and even some scientific papers on magnetism, speak of this end of the magnet as the north pole of the magnet. From this they are driven to call the magnetic pole of the earth situated in the northern hemisphere the earth's south magnetic pole.

The following appears in a popular account of the mariner's compass. Speaking of an iron bar held in a vertical position in the northern hemisphere, it says "its lower end is nearer the earth's south pole;" then a note is added, "that is, the pole similar to the south pole, and capable of attracting the north pole of an ordinary magnet. This is always spoken of as the earth's south pole, although north in geographical position."

In order to avoid the confusion which is thus caused, it has been proposed by Sir George Airy to color the poles of magnets blue and red. The blue end being the one which has magnetism similar to the northern regions of the earth, and the red end magnetism similar to the southern regions of the earth. The adoption of this proposal generally would do much to avoid the confusion and difficulty which is felt by practical men in understanding the principles of magnetism in connection with the mariner's compass.

It is quite proper to mark the point of the compass card which points to the north with an N, and the point which points to the south with an S, and these points may without any confusion be called the north and south points of the card; but when the end of a magnet which is attracted toward the earth's northern magnetic pole is spoken of as having northern polarity, or is marked with the letter N, this gives a wrong idea, and produces confusion in the mind of the learner. The confusion is annulled when Sir George Airy's excellent proposal is adopted.

The magnetic poles of the earth do not coincide with the astronomical poles. In the northern hemisphere the magnetic pole is situated to the N.N.W. of Hudson's Bay. The southern magnetic pole has not been reached by any one, but it was so nearly approached by Sir James Ross that there can be no doubt of there being a southern magnetic pole at a point to the south of Tasmania.

Now, a magnetic needle when influenced only by the earth's magnetic attraction points to the magnetic pole and not to the true or astronomical pole.

Thus the north and south as shown by compass do not usually agree with the astronomical north and south. The angle which the compass needle is deflected from the astronomical north when influenced by the earth's magnetic force is called the variation of the compass. The variation differs in different parts of the earth. Charts showing the variation of the compass in different parts of the world have been published by the Admiralty. The variation at any particular place does not remain the same always. Ever since accurate observations of terrestrial magnetism were made, the distribution of it over the earth has been constantly changing. As an example of the changes which have taken place in the direction of the earth's magnetism, I may tell you what has occurred in London since the middle of the 16th century.

The variation in 1580 was 11° 15′ to the east of the true north. The easterly variation gradually diminished till 1659, when the needle pointed to the true north; after that it began to point to the west of north, and the westerly variation continued to increase until the year 1820, when the needle pointed 24½° to the west of true north. From that time until now the westerly error has been diminishing. At the present time the variation at Greenwich is 17° 54′ westerly, and it is decreasing about six minutes annually. It is important, when taking the variation from a chart, to correct it up to date. If the chart is five years old, an error in the variation of nearly one degree may be made in some places.

The compass used on board all ships at the present time is substantially the same as that described by Gilbert three hundred years ago. It consists of the compass card, the bowl with gimbal ring, and the box or binnacle for supporting the bowl. The ordinary compass card now used is made of a thin disk of mica or cardboard, to the lower side of which are attached magnetic needles made of parallel straight bars of flat steel, with the breadth of the bar perpendicular to the card. In the Admiralty standard compass there are two pairs of needles; in the compasses of merchant ships there is generally only one pair of needles attached to the card; in Sir William Thomson's compass there are four pairs of very small round steel needles hung from the rim of the card by means of silk threads. The circumference of the card is divided into degrees, and inside the circle of degrees the card is further divided into points and quarter points. In the center of the card there is a jeweled cap, which bears the whole weight of the card and needles on a fine point of hardened steel, or of a natural alloy of iridium and osmium, which is much harder than steel, and is not liable to rust. The compass bowl is a circular box formerly made of wood, but now made of brass or copper with a glass cover on the top. The bowl, with a weight attached to its bottom, is supported on a brass ring at opposite points by pivots projecting from it, so as to allow the box to swing inside the ring. The ring is similarly supported on the binnacle by pivots projecting from it, the line of these pivots being at right angles to the line of the pivots on the bowl. When thus supported, the compass bowl, which is said to be supported on gimbals, can always take up a horizontal position.

The bearings of the bowl and gimbal ring are usually round journals. In order to give greater freedom to the bowl to assume a horizontal position, Sir William Thomson uses knife edges instead of round journals, and to calm the vibrations of the bowl, he attaches a hemispherical shell to the bottom of the compass box. This shell is nearly filled with a viscous oil. The flowing of the oil on the bottom of the shell prevents the bowl getting into a swing. To prevent the vibrations from the engines of a steamer affecting the compass card, it is found necessary to hang the bowl and gimbal ring by an elastic suspension from the binnacle. This is usually done with India rubber bands; but Sir William Thomson has adopted a novel elastic suspension which has proved remarkably successful, particularly so on board ships of war during the fire of heavy guns. He uses an elastic ring of brass wire made up similarly to a rope grummet ring, which is well known on board ship. From this elastic ring the gimbal ring is hung by brass chains.

The Admiralty standard compass is only 7½ inches in diameter, and the steering compasses used in the British navy are now usually 10 inches in diameter. In the merchant service the larger card is preferred, and it is almost always 10 inches or more in diameter. In some of the large ocean steamers compass cards of 15 inches diameter have been used, but a card of this size is only suitable for steering compasses, where it is important to have the space between each degree as large as possible, so that the steersman may notice at once when the ship goes off her proper course. For standard compasses, a card of 10 inches diameter appears to be the most suitable. A 10 or 12 inch compass card is much steadier in a heavy sea than a similar card of 6 or 7 inches in diameter, and it is this advantage which has led to the 10 inch card being generally adopted in the British merchant service.

Until a few years ago it was usual to make compass cards with long and powerful magnets, as it was considered that the greater the "magnetic moment" of the needles the better the compasses. In 1874 Sir William Thomson pointed out that the greater the magnetic moment, all other circumstances being the same, the more unsteady will the compass be when the ship is rolling. With the heavy compass cards universally used at that time, the magnetic needles required to be made large and strong, in order to have sufficient directive force to overcome the friction between the cap and bearing point, otherwise the compasses would have been sluggish, and would not have indicated accurately and quickly any changes in the ship's head. Another important reason for making the magnetic moment as small as possible is to allow of an accurate correction being made of one part of the error of the compass, called the quadrantal error, which is produced by the iron of the ship. When large compass needles are used, this correction is vitiated by the inductive action of the large needles on the soft iron correctors. To allow of the whole compass error being really well corrected by means of magnets and soft iron of convenient size, it is necessary that the needles should have a small magnetic moment, and that they should be as short as possible, consistent with their being powerful enough not to allow of any frictional error.

One of the first to note the effect produced on the mariner's compass by the iron used in the construction of ships was Wales, the astronomer of Captain Cook's voyages; but no systematic attempt was made to investigate the subject until the beginning of the present century, when Captain Flinders, an officer in the Royal Navy, made a voyage to Australia. He observed that there was a difference in the indications of the same compass, amounting to as much as 4½ degrees, when placed in different positions in the same ship; and, further, that with the compass in the same position its indications differed when the ship's head was in different directions. He found that with the ship's head north or south no deviation was produced, but that with the ship's head east or west there was a maximum deviation. In the northern hemisphere, with the compass placed in the ordinary position near the stern, he found that the north point of the compass card was attracted toward the bow. On proceeding south he noticed that this attraction of the north point of the compass cards toward the bow diminished gradually, and that at the equator there was no attraction from the iron of the ship. In the southern hemisphere the effect of the iron of the ship was reversed, and the north point was found to be repelled from the bow of the ship. The iron in such vessels as Captain Flinders'—namely, wooden sailing ships—was principally employed in the shape of vertical rods for stanchions, and would be of the quality known as soft iron.

There are two qualities of iron, which are differently affected when brought under magnetic influence, soft iron and hard iron.

Soft iron is iron which becomes magnetized almost or quite instantaneously when brought under the influence of a magnetizing body, and which loses its magnetism as soon as that influence is removed. Hard iron, on the other hand, does not acquire magnetism so easily, but when once it is magnetized it retains it permanently, even after the magnetizing force is removed.

I have here a piece of soft iron, and when I hold it in a vertical position you will observe that the upper end attracts the red end of this suspended needle; the

* A recent lecture before the Society of Arts, London.

lower end attracts the other pole. Now I will reverse the bar end for end, and you will see that the lower end, which formerly was up and attracted the red end, now repels it and attracts the opposite end, and the end which is uppermost now attracts the red end, instead of repelling it. Thus, by simply reversing the bar end for end, the magnetism in it has been reversed. Further, if I hold it in an east and west direction, it will not produce any effect on the needle, provided the bar is very soft. If I strike the bar while in a vertical position, the magnetism will become to a certain extent fixed, so that when I reverse it end for end, the magnetism in it does not at once become reversed. On the contrary, you will see that the upper end now repels the red end, instead of attracting it, as formerly. If I leave the magnet hanging in this position for some time, it will gradually lose the magnetism which was hammered into it, or I can knock the magnetism out of it at once by striking it gently. But if I take a bar of soft iron, large enough in diameter in proportion to its length, I cannot make the magnetism in it become fixed by striking the bar. This fact, we shall see, is of considerable importance in the correction of one part of the error of the compass caused by the iron of the ship. This bar, when held vertical, is influenced by the earth's magnetic force, and becomes magnetized by induction, as it is called. The lower end, which is toward the north pole, takes magnetism of the opposite name, or true southern polarity, or becomes a red pole. The upper end takes magnetism similar to the earth's north pole, or true northern polarity, or becomes a blue pole. The earth in this case is the magnetizing body.

When the bar is held horizontally in an east and west direction, there is no magnetic force acting in the direction of the length of the bar, and consequently the bar does not perceptibly show any magnetic properties.

We will now return to the consideration of Captain Flinders' observations. I have told you that in the northern hemisphere he found an attraction of the north point of his compass needle toward the bow, in the southern hemisphere toward the stern. His explanation of this was that the vertical iron of his ship became magnetized by induction from the earth. In the northern hemisphere the upper end of all the vertical iron attracted the north point of his compass. At the equator, where there is no vertical magnetic force of the earth, no effect was produced by the iron. In the southern hemisphere, where the earth's vertical magnetic force is reversed from what it is in the northern hemisphere, the upper end of the vertical iron repels the north point of the compass.

As the compass in the old sailing ships was placed near the stern, there would be a larger amount of iron before the compass than behind it, and as the compass was placed on deck, the upper parts of the iron would be nearer the compass needles than the lower parts. Therefore, in the northern hemisphere, the north point would be attracted toward the bow and in the southern hemisphere toward the stern.

Captain Flinders not only gave the correct explanation of the effect of the iron on the compass, but he also proposed a method of correcting the errors thus produced, which is of great utility in the correction of compasses of the iron ships of the present day. He suggested that a bar of soft iron should be fixed in a vertical direction before or behind the compass to counteract the effect of the induced magnetism of the iron of the ship.

Captain Flinders dying shortly afterward, the subject received little attention until about the year 1817, when Professor Barlow engaged in a series of most interesting experiments on the effect produced on a compass needle by masses of iron magnetized by induction from the earth. These researches were undertaken with a view of correcting the errors of the compass caused by masses of iron such as guns, and one result of the greatest importance which Barlow obtained was that the effect produced on the compass by a hollow globe is the same as that produced by a solid one, provided there is a certain thickness in the metal of the hollow one in proportion to its diameter. He proposed to correct the deviations of the compass by applying a circular plate of soft iron, which would produce errors of the same amount as the deviations produced on the compass by the iron of the ship. This method was applied to some ships in the British Navy with success, but the introduction of iron into the construction of the hulls of the ships shortly afterward completely altered the problem, and other methods had to be adopted in consequence.

In the year 1824, Poisson, the distinguished French mathematician, published a mathematical investigation of the theory of magnetic attraction and repulsion, and discussed the magnetic actions on a horizontal needle of the earth directly and of iron globes rendered magnetic by the inductive action of the earth. In 1838, he adapted the results of his previous investigations to observations made on board ship, for the purpose of determining the errors of the compass caused by masses of iron symmetrically placed on each side of the fore-and-aft section of the ship. These investigations of Poisson furnished the basis for the further development of the mathematical theory of the deviation of the compass on board an iron ship. But he had purposely confined himself in his investigations to the case of transient induced magnetism in soft iron, and had omitted what soon after his time became of the greatest importance, namely, the action of the ship as a permanent magnet.

So far, we have been considering the deviations in wooden ships, in which the iron used was of small amount, and almost entirely of the nature of soft iron. The deviations found in these vessels were small in amount.

We now come to the period when iron began to be used for the construction of ships, and large masses of iron for the machinery of steamships.

In 1838, Sir George Airy, the late Astronomer Royal, undertook, at the request of the Board of Admiralty, a series of experiments on the deviations produced on the compass on board two iron vessels, the Rainbow and Ironsides, for the purpose of discovering the laws which govern the disturbance.

The results which he obtained from these experiments, and the mathematical theory of the magnetism of an iron ship which he deduced from them, were given to the Royal Society in 1839. In this important paper he showed how the errors of the compass, depending on the influence of the magnetism of the ship, may be perfectly corrected by steel magnets and masses of soft iron placed in the neighborhood of the compass. His system of correction of the compass was pretty generally adopted in the merchant service soon after it was proposed, and now it is universally employed, not only in the merchant service, but also in the navies of this and other countries.

Since the time of Sir George Airy's experiments on board the Ironsides and Rainbow, our knowledge of the problem of ships' magnetism has been largely increased. Airy himself continued his investigations for many years, and communicated his results in papers to the Royal Society.

The late Mr. Archibald Smith, an eminent mathematician and lawyer, in addition to his professional work as a barrister, devoted himself for many years with great energy to the advancement of this question. By transforming the orginal equations of Poisson to a more practical and simple form, he was able to devise a system of correction and harmonic reduction of the observations of the compass which has been of the greatest service, not only in the branch of practical science for which it was originally intended, but also in many other departments of practical physics. In conjunction with Sir Frederick Evans, the late Hydrographer of the Admiralty, he revised the Admiralty Instructions regarding the compass, which in their new form appeared as the "Admiralty Manual on the Deviations of the Compass." This important work has been appreciated not only in this country, but throughout the civilized world. It has been translated into Russian, French, German, and Portuguese, and has also been adopted by the Government of the United States. Having referred to the work of Sir F. Evans, I may take this opportunity of giving expression to the regret which must be felt by all interested in the navigation of iron ships on account of his recent death. The communications he made to the Royal and other societies on the subject of the magnetism of iron ships were of great value.

In addition to Airy, Archibald Smith, and Evans, the names of Sabine, Scoresby, Captain Johnson (of the Compass Department of the Admiralty), Towson and Rundell (secretaries of the Liverpool Compass Committee), must always be mentioned with gratitude for the services they rendered in the elucidation of the compass problem after the introduction of iron ship building. In France, Lieut. Collet, of the French navy, has devoted much attention to this subject, and has recently published a very valuable theoretical and practical treatise on the compensation of the compass, with or without bearings.

When considering the magnetic properties of an iron ship, it is convenient to imagine the iron divided into classes, hard iron and soft iron; not that any of the iron or steel used in the construction of ships is either perfectly hard or perfectly soft. Any ordinary plate used in the construction of a ship, whether it be iron or what is called steel, will become magnetized by induction from the earth, and if subjected to concussion from hammering it will become more highly magnetized, and retain a portion of that magnetism in a permanent condition.

Let us consider the case of an ordinary plate of iron, as shown in the diagram below (Fig. 1), placed up-

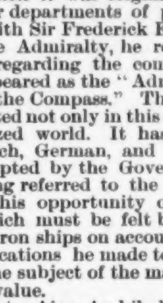


FIG. 1.*

right in the magnetic meridian in the northern hemisphere. The upper edge, from end to end, will be found to attract the north point of the compass card, or to have acquired blue magnetism, while the lower edge will attract the south point of the compass card, or it will have acquired red magnetism. Between the top and the bottom there will be a neutral zone running along the length of the plate, and this zone will be inclined to the horizon. In a square plate its direction will be at right angles to the dipping needle at the place of observation, but in an oblong plate its direction will be more in the length of the plate. Now if this plate were to be hammered, as is done when it is riveted into a ship, it would acquire some permanent magnetism, so that in whatever position it were held it would indicate a distribution of magnetism similar to what is shown in the diagram (Fig. 1). But superimposed on this permanent magnetism there would still be magnetism induced by the magnetic force of the earth.

Now what I have described for one plate takes place during the construction of an iron ship with each plate. The result is that the whole ship becomes magnetized and the distribution of that portion of the magnetism which is thus hammered into the ship depends on the direction of the ship's head while building.

It was Dr. Scoresby who first called attention to the remarkable fact that the magnetic character of a ship depends essentially on the direction of her head while building, and that this original magnetism is subject to great changes after launching. The diagram (Fig. 2) shows the distribution of this magnetism, which is usually called the permanent magnetism, for ships built in this country with their heads in the directions north, south, east, and west. In the upper drawing, the ship is represented as having been built with her head magnetic north. In this case, the upper part of the stern being farthest from the north acquires blue magnetism strongly, while the lower part of the bow acquires red magnetism strongly. Between these extremes there is a neutral zone running from the upper part near the bow to the keel near the stern post. The intensity of the blue and red magnetism of the stern and bow gradually diminishes toward this zone. In such a ship the north point of the compass will be attracted toward the stern and the south point toward the bow.

* In these diagrams the blue is marked by the cross lines, the red by single lines.

The next drawing represents a ship built head magnetic south. Here we have the upper part of the bow a powerful blue pole, while the lower part of the stern is a powerful red pole. In this case, the north point of the compass will be attracted toward the bow.

With the ship built head east or west, the whole upper part of the ship will have blue magnetism and the lower part red magnetism; but in the

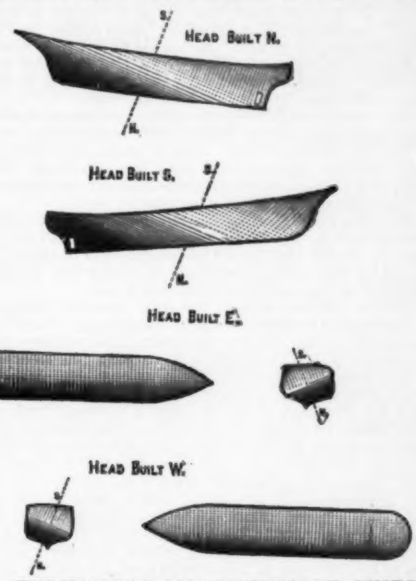


FIG. 2.—PERMANENT MAGNETISM OF SHIPS.

former case, the starboard side being further from the north will be more powerfully blue than the port side, so that the north point of the compass card will be attracted to the starboard side; whereas, with the ship built west, the port side will be more powerfully magnetized than the starboard side, and the north point of the compass card will be attracted to the port side.

The resultant of all the magnetism thus acquired gives rise to a single disturbing force of the same character as that which would be produced by a permanent steel magnet. I have spoken of this part of the magnetism of the ship as permanent magnetism. It is permanent in direction, but it is liable to change in amount with time, especially so when the ship is new. The change is greatest just after launching, and if the ship is then turned round and kept with her head in the opposite direction to what it was before launching, a large part of the magnetism which is not firmly hammered into the iron will be lost. It is most important that every new ship, after launching, should be turned round and kept with her head in the opposite direction while fitting out for sea, so that she may lose as much as possible of the magnetism which has not been firmly hammered into her before having her compasses adjusted.

This is a matter which is very much overlooked at present. It is most desirable that naval architects or others who superintend the construction of iron ships should insist on having it done. I would suggest that a clause should be added to all the contracts for new ships, that, after launching, the ship should be turned round and kept, while fitting out, with her head as nearly as possible in the opposite direction to what she was on the stocks. I have known many cases where this has not been attended to, in which the magnetism changed so much within a few days as to cause serious inconvenience and danger in the navigation of the ship. One instance, which came under my notice a few years ago, will show the importance of having the ship turned round. A large passenger ship was built with her head nearly south, and fitted in the same direction. Her compasses were carefully adjusted, and after that she remained swinging to her anchor in a tide way, so that her head turned to different directions each tide for a week. Before she left for her first voyage, I went on board to ascertain the errors of her standard compass, as I expected to find a considerable change. I found on some points there was as much as 10° of difference of error from what there had been a week before. The ship, by swinging to her anchor for a week, had lost an amount of magnetism sufficient to produce an error of ten degrees on the compass. Since that time several other ships similar in every way have been built by the same builders for the same company, but they have been turned round after launching, and there has been comparatively little change in their magnetism. The importance of this was pointed out thirty years ago by Dr. Scoresby, and recommended by the late Sir Frederick Evans, but shipbuilders and others are in much need of being reminded of it now.

The effect of the magnetism of the hard iron is to produce an error on the compass which vanishes when the ship's head is on two opposite points, and attains a maximum amount in each semicircle as the ship turns round. It has, therefore, been called a semicircular error. I may illustrate the effect of the permanent magnetism of the ship by fixing a steel magnet on this frame, and turning it round the compass. The frame will represent a ship in which the magnetism is altogether permanent magnetism. When the line of the disturbing magnet is in a line with the compass needles no deviation is produced. As the ship's head is turned round the deviation increases, until it attains a maximum, when the line of this disturbing force is at right angles to the compass needles. It then gradually diminishes and again comes to zero. Continuing to turn the ship, we find a deviation again appears, but in the opposite direction to what it was in the other semicircle. It attains a maximum, and comes to zero at the place of starting.

You will now readily understand that as this magnetism which is hammered into the hard iron of the ship gives rise to forces, the resultant of which is a single magnetic force acting in a definite direction in the ship, its influence on the compass may be neutralized by placing a steel magnet with its poles in the opposite direction, at such a distance from the compass that it will exactly counterbalance the magnetism of the ship. This is one of the plans which Sir George Airy proposed in 1838, and which is used for correcting the standard compasses in the navy. The amount and direction of the ship's permanent magnetism at the position of the compass is first determined. A steel magnet is then selected, and the distance found by trial where it will produce the same force on a compass needle as the ship's magnetism does at the position of the compass on board. A hole is bored in the wooden stand at the right distance from the compass needle, and the magnet inserted with its poles acting in the opposite direction to the ship's magnetism.

The second of Sir George Airy's plans, and which is the simplest and most convenient, is generally adopted in the merchant service. It is to apply two sets of magnets, one set fore-and-aft and the other set thwartship, to counterbalance the fore-and-aft and thwartship component of the ship's magnetism.

We have now to consider the action of the soft iron magnetized by induction from the earth, and it is necessary to divide this into two parts—the magnetism induced by the earth's vertical force, and the magnetism induced by the earth's horizontal force.

All the vertical iron of the ship becomes magnetized by induction from the vertical component of the earth's magnetic force. In the northern hemisphere, the upper parts of the vertical iron attract the north point of the compass card; in the southern hemisphere the south point. The effect of vertical iron on the compass may be illustrated by moving a vertical rod of soft iron round the suspended needle. Let the bar be kept with its upper end about the same level as the needle. Now, in whatever position the upper end of the bar is held, the north point will always be attracted toward it. Consequently, when the bar is held in the line of the needle, there is no deviation, but when it is in a line at right angles to the direction of the needle a maximum error is produced, which is easterly when the bar is to the east of the needle and westerly when it is to the west. Thus we have a semicircular error produced by a vertical bar carried round the compass. All the vertical iron acts similarly, and produces a semicircular error as the ship is turned round in azimuth. The amount of this error will vary in the same ship according to the position of the compass with regard to the vertical iron. In some positions, where the iron is symmetrically distributed fore-and-aft, and also athwartship, the attractions on opposite sides may neutralize each other, and no error will be produced, while in other positions there may be large errors. For a compass in the same position in the ship, the error will vary in different parts of the world as the vertical force of the earth changes.

The force on the compass due to magnetism induced in the soft iron of the ship by the vertical component of the earth's magnetism is constant in direction in the ship, but it varies in amount in proportion to the earth's vertical force. The error which it produces on the compass varies, therefore, directly as the earth's vertical force, and inversely as the earth's horizontal force, or, what is the same thing, directly as the tangent of the dip.

The error caused by induction in vertical iron is usually corrected along with the permanent magnetism by means of steel magnets. This plan is objectionable, except for ships trading in the same latitude, because the earth's vertical force, which produces the error, varies in different parts of the world, whereas the force applied to correct it remains constant. This error is really the same as that observed by Captain Flinders in his wooden ship, and the proper way to correct it is that which he suggested, namely, a bar of vertical soft iron placed in such a position as to produce a force on the compass needles equal and acting in an opposite direction to the ship's force. The Liverpool Compass Committee had such a bar fitted to the steering compasses of several ships, and Captain Lecky has applied it with remarkable success to the compasses of several ships in the merchant service. The binnacle of Sir William Thomson's compass is fitted with a brass tube for holding this Flinders bar, and whenever the requisite information can be obtained for determining the size of bar required for any particular compass in a ship, it is applied.

The application of the Flinders bar has been of great service in a large number of ships. It is particularly useful for mail steamers making regular passages between this country and the southern hemisphere. In such cases, after the ship has made one or two voyages, it is quite possible to adjust the length of the bar so that the change in error from vertical induction will not exceed two or three degrees in going from England to the Cape of Good Hope.

When a compass is placed in a new ship, it is impossible to tell with accuracy how much of the semicircular error should be corrected by Flinders bar, and how much by steel magnets. To determine the amount of Flinders bar required, it is necessary to have observations of the deviations in two places differing considerably in magnetic latitude. But even in a new ship an experienced adjuster can generally place a bar so that there will at all events be less change with change of latitude than if the whole semicircular errors were corrected with steel magnets. Similar ships with the compass placed in similar positions will generally require about the same amount of Flinders bar. As an illustration, I may refer to the Donald Currie mail steamers, between London and the Cape. Ten ships for this line have been supplied with the binnacle fitted with the receptacle for the Flinders bar. It has been found, after making one or two voyage to the Cape, that in all these ships the Flinders bar is required to be placed on the fore-side of the binnacle, and that the amount of error to be corrected in London varies from ten to fifteen degrees. In six of the ships the error to be corrected was 13 degrees. Now, in any other new ship similar to these, and with the compass similarly placed, it would be quite safe to apply a bar at the first adjustment to correct about 13 degrees in London. If the whole semicircular error in these Cape mail steamers were corrected in this country by steel magnets, there would be a change in the deviations on east and west courses of from 16 to 24 degrees every voyage to the Cape. The application of the Flinders bar diminishes the amount of change in deviation by that amount. In order that the Flinders bar may not give rise to error through becoming permanently magnetized, it should be large enough in diameter in proportion to its length not to become magnetized by hammering.

We have seen that the permanent magnetism of the ship and the induced magnetism from the earth's vertical force both produce an error of the same nature as the ship's head is turned in azimuth, namely, a semicircular error, but the deviation produced by the induced magnetism from the horizontal force follows a different law.

In this case, as the ship is turned round in azimuth, the direction of the force on the compass due to magnetism induced by the earth's horizontal magnetic force remains fixed with regard to the earth's magnetic meridian, but changes with respect to the direction of the ship's head. With the permanent magnetism, and with the magnetism induced in vertical iron, the direction of the disturbing force remained constant in the ship and therefore varied in space as the ship turned round, but with the magnetism induced in horizontal iron the direction remains constant in space. Let us see how this affects the compass.

It may be illustrated by this arrangement: In this cradle there are two hollow globes of cast iron, with their centers on a level with the compass needles. The result is that the magnetism induced by the vertical component of the earth's magnetism does not affect the compass, and the whole disturbance is caused by horizontal magnetic force. This will represent an actual ship with regard to its horizontal magnetic force, with a compass placed on the central fore-and-aft line, so that the iron is symmetrical on each side. Now, as the globes are turned round the compass needle, the induced magnetism in the globe changes in direction with respect to a fixed meridian of the globe.

The line joining the center of the globes will represent the length of the ship. I will now turn the cradle containing the globes. When the line joining the center of the globes is north and south, the northern parts of the globes will acquire red magnetism and the southern portions blue. In this position no deviation is produced, because the resultant of the horizontal lines of magnetic force will be in the magnetic axis of the compass, but the force acting on the compass needles will be increased. As the northern globe is turned toward the east, the north point of the compass card will be drawn toward the east, and the deviation will increase until the direction of the globes is N.E. From this point the deviation gradually diminishes until the globes become east and west, when no deviation is produced, but the directive force acting on the needles is diminished. Now, as we turn the globes further round, the north point of the compass card will be drawn toward the west, and the deviation will increase until the globes are S.E. and N.W. It then diminishes until the globes are in the north and south line, when there will be no deviation, but the force will be increased. Continuing the operation in the other semicircle, we shall obtain a repetition of these results. With the globes S.W. and N.E. easterly deviation will be found, with the globes east and west there will be no deviation, and when the globes are N.W. and S.E. there will be westerly deviation. The effect of magnetism induced from the horizontal force of the earth may be illustrated by the diagram (Fig. 3), which represents a horizon-

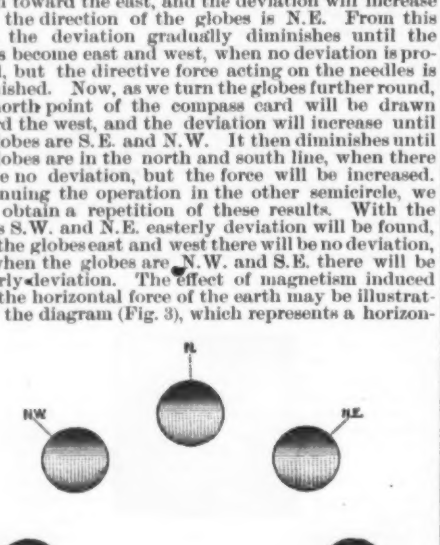


Fig. 3.—INDUCED MAGNETISM FROM HORIZONTAL FORCE.

tal plate of iron placed in different positions round a compass needle. Thus the magnetism induced by the earth's horizontal force causes a deviation which attains a maximum in each quadrant, and is of opposite name in each adjoining quadrant. It has, therefore, been called quadrantal error.

Now, the magnetic force which causes the quadrantal deviation being induced by the horizontal force of the earth, its magnitude is proportional to that horizontal force, and as the directive force on the compass needles is also proportional to the same horizontal force, it follows that the deviations produced by the magnetism induced in horizontal iron are independent of changes in the earth's force, and will be the same in all parts of the world. The quadrantal error is corrected by placing masses of soft iron on each side of the compass. As a rule, where a standard compass is placed in the center line of the ship, the iron is symmetrically placed on each side of the compass. In such cases the quadrantal error vanishes on the four cardinal points N. E. S. W., and attains a maximum easterly deviation at N.E. and S.W., and a maximum westerly deviation on N.W. and S.E. It is corrected by placing the soft iron on each side of the compass, in the thwartship line. The soft iron may be in the form of iron chain, or cast-iron cylinders, as proposed by the Liverpool Compass Committee, or iron spheres, as used by Sir William Thomson. There is an objection to the use of chain, particularly when used with powerful compass needles; the links may become permanently magnetized from being too close to the ends of the needles.

In some exceptional cases, when the iron is not symmetrical round the compass, we may also have a quadrantal error which has a maximum on the four cardinal points, and vanishes on the four quadrantal points. This occurs in some of the turret ships, but it is so uncommon in ordinary ships, that it is not necessary to go fully into it now. It may be corrected by placing the soft iron on opposite sides of the compass, obliquely to the thwartship line. In these exceptional cases there is usually a small constant error of the same name on all courses remaining, which must be allowed for.

Since the quadrantal error remains the same all over the world, and does not alter with time to any appreciable extent, it is very desirable to have it properly corrected at first. When it is properly corrected, the readjustment of the steel magnets from time to time, as errors arise from change in the permanent magnetism of the ship, becomes very simple.

Hitherto I have only considered the case in which the ship is supposed to be upright, but when the ship heels over, other influences come into action which produce errors, often of a very serious amount. The greatest errors from heeling occur in iron ships when they are upon northerly or southerly courses. When the ship's head is east or west, there is no heeling error. In general, with ships built in the northern hemisphere, the north point of the compass is drawn toward the high side of the ship while in northern latitudes. The error is usually greatest when the ship is built with her head in a northerly direction. In such ships the heeling error diminishes on going toward the southern hemisphere. With ships built in a southerly direction, if the compass be placed near the stern, the heeling error is usually small, and in some cases the north point is drawn to the low side of the ship. When the latter cases occur, the heeling error will increase as the ship proceeds to the south. The heeling error may be corrected for any particular latitude, by placing a magnet, which is vertical when the ship is upright, and becomes inclined to the vertical as the ship heels over, under the center of the compass at such a height as to neutralize the ship's vertical force.

Although the compas on an iron ship may be accurately corrected at any particular time and place by the methods which I have briefly described, it would be a great mistake to suppose that the indications of the compass can be depended on for any length of time afterward without constantly ascertaining the errors by means of observations. In every ship, whether old or new, but especially in a new ship, during the first years, the only safe plan is to expect the errors to change, and never to lose an opportunity of checking the indications by observations of the sun by day and stars by night.

It cannot be too often impressed on those who have the charge of iron ships that the mariner's compass is no trustworthy guide, placed, as it is, in the midst of such changing forces as the magnetism of an iron ship. I have already referred to the changes which occur in the magnetism of new ships, and which may give rise to serious errors. No doubt the amount of change diminishes in time, and after some years the magnetism of the ship becomes, to a certain extent, constant, but it is always liable to alteration by shocks from the sea or other causes.

The only definite and scientific information which has been obtained regarding the changes in the magnetism of ships during the last thirty years has been supplied by the Compass Department of the British Navy. An interesting paper has recently been given to the Royal Society by Captain Creak, F.R.S., on the deviations of the compasses of certain classes of her Majesty's Navy, in which he has recorded the magnetic history of a large number of iron armor-clad, iron and composite ships. The tables which are appended to his paper show that, after a few years' service, the magnetism due to the hard iron becomes to a very great extent permanent, but I do not think that it would be safe to expect the same result with ships of the merchant service. The ships of the navy are constructed of much thicker plates than those of the merchant service, and we may suppose that the vibration from the engines and shocks from the sea would have a greater effect in producing a change in the magnetism of the latter. Another reason for expecting the standard compasses to act more satisfactorily in the ships of the navy is that the greatest care is exercised by the Compass Department in the selection of the best possible position for the standard compass, with respect to the surrounding iron; whereas in the merchant service, in many cases, no precautions are taken for the selection of a good position for the standard compass.

I have now to refer to another part of the magnetism of the iron which in many ships plays an important part, and gives rise to deviations which are frequently very puzzling to the navigator. This is called by some writers "Retentive Magnetism," but perhaps a better name for it is sluggishness of the ship's magnetism. It is the error which is found when a ship's course is changed after having been steaming in the same direction for some days. The error is also found after a ship has been lying in the dock for a considerable time. This is particularly observable in vessels trading between this country and North America. It frequently happens on the voyage from here to New York, after steaming for five or six days on a westerly course, when the vessel's head is turned to the north, an error of several degrees of westerly deviation is found. On the other hand, after coming from New York to this country, steering for several days on an easterly course, when the ship's head is turned to the north, an error of several degrees of easterly deviation is found.

It may also be observed with ships going to India. After steaming along the Mediterranean in an easterly direction, when the ship's head is turned to the south, westerly deviation is frequently found; but when coming home, after passing through the Mediterranean steering west, when the ship is turned to the north, westerly deviation is found. If the ship be kept for a few days on the second course, the error will gradually diminish. The explanation of this is that the ship acquires some additional magnetism, which becomes temporarily fixed by the shaking from the screw and shocks from the waves. So long as the ship remains on the same course, no deviation from this cause is produced on the compass; but as soon as the course is altered, the side of the ship which was farthest from the north

having acquired a dose of blue magnetism, attracts the north point of the compass, and produces the deviation observed. Now this magnetism, not being firmly fixed into the iron of the ship, is gradually shaken out when the ship is on another course. The amount of this error cannot be predicted at all. Captain Lecky has found it to amount in some cases to as much as 10 degrees after steaming in an easterly or westerly direction for six or seven days. The following rules have been given by Sir William Thomson as a warning regarding the sluggishness of ships' magnetism:

1. After steering for some time on westerly courses expect westerly error if you turn to the north, or easterly error if you turn to the south.

2. After steering for some time on easterly courses expect easterly error if you turn to the north, or westerly error if you turn to the south.

In conclusion, I may just give a few words of warning on a point of considerable importance in connection with the electric lighting of ships and the action of the current of electricity on the ship's compasses. During the last few years many passenger steamers have been lighted with electricity, and often only a single wire is used, the ship's side taking the place of the return wire. Now, in such cases it is quite possible that the wire may be placed in such a position and at such a distance from the compass that the current flowing through it will produce a large error.

Take, as an example, a main lead from the dynamo machine, to light up a saloon with 100 lamps, or more. It may run along nearly underneath the position of the standard compass. The current may be taken at 100 amperes. In such a condition of affairs, the error produced on the compass will amount to as much as 7½ degrees when the wire is at a distance of 30 ft. Now, this error will only be produced at the time that the current is flowing to light up the lamps, and it may never be detected by the officers of the ship. The observations for determining the error of the compass are usually made during the day, when the electric light is not required. The captain may therefore determine his compass error every day, and set his course quite correctly, but for some hours at night the ship may be going several degrees off her proper course, although she is being steered correctly by the compass.

This refers to a single wire system and a continuous current machine, but if an alternate current machine be used, no effect will be produced on the compass, even with a single wire, and the ship's side as a return. Also with a continuous current machine the danger may be entirely avoided by using a double wire system with the two wires close together. It is essential that both wires should be well insulated from the ship's side. A want of insulation in one of the wires, although there may be no change observable in the lighting, may produce as much error on the compass as if there were only a single wire. So far as I know, there is no great advantage in the single wire system over the double wire, except it be a slight saving in the first cost. It would, therefore, appear that for the safety of the ship, when a continuous current machine is used for lighting, two wires, well insulated, should always be employed, and that the insulation of the wires should be tested periodically to make certain that no fault has occurred.

THE DEVELOPMENT OF ELECTRICITY ON THE CONVERSION OF VAPOR INTO WATER.

By L. PALMIERI.*

DURING the course of some researches that I have been pursuing since 1850 upon atmospheric electricity, I have especially endeavored (1) to use only methods and instruments that were capable of yielding results which required no corrections, and which admitted of comparison, and (2) to so simplify the apparatus that they could be intrusted even to observers of very ordinary education.

I early ascertained that the electricity of the air increases with the relative humidity; and that strong tensions (during the continuance of which, conductors exposed to the free air furnish sparks) announce with certainty the near-by advent of clouds, fogs, and mists, and, with much probability, of falls of rain, snow, or hail, either at the point at which one is situated or at distances from such place, and which are capable of reaching several miles.

It is to be remarked that these exceptional tensions (which correspond to thousands of electro-metric degrees) follow the phases of the rain. They begin with it, last as long as it does, and end at the same time that it does, according to laws that I formulated in 1854. By reason of this, I believe that we can, without error, attribute the origin of atmospheric electricity to the condensation of vapor, as Volta appears to have suspected.

Desirous of supporting these theories (which I had emitted only in basing myself upon a long series of minute and direct observations) by facts, I undertook a series of experiments in 1862, which proved convincing, but which, for want of publicity, have remained nearly ignored; and no one has repeated them.

Other experiments were tried that led to no precise conclusions; and, finally, a number of theories that were often devoid of all experimental sanction succeeded one another, and were in some cases rejected as soon as accepted.

The analyses that Messrs. Kalischer, Gerland, Faye, Edlund, and others have very recently been pleased to make of the memoir in which I summed up my labors upon atmospheric electricity have again called the attention of meteorologists to this subject; but objection has been made to the difficulties and expense of my experiments of 1862. It has even been printed in France (through error, it is true) that the signs of electricity that I have been able to substantiate are insignificant. I have since been endeavoring to simplify my preceding arrangements as much as possible, so that it might prove easy and inexpensive to have my own experiments repeated in every cabinet of physics, and I have succeeded in this by arranging the experiment as follows: Upon a well insulated support, I place a platinum cup of about four and a half inches diameter, and put it in communication, through a platinum wire, with the lower disk of the condenser of a Bohnenberger electroscope. Upon operating as usual, the gold leaf is observed to remain immovable, and the result will be the same if we pour into the cup water of the temperature of the surrounding air. The cup is then filled with cracked ice, and the upper disk is removed after being put for an instant in communication with the earth, as usual. The gold leaf will then be seen to clearly show positive electricity.

In order to make the experiment more striking, it is well to break the communication of the lower disk with the platinum cup at the moment the upper disk is removed. In the face of such a result, I have thought it superfluous to use cooling mixtures in order to obtain much lower temperatures, believing it better not to rob the experiment of that character of simplicity which shields it against all debate.

As to complementary details, I shall add that the Bohnenberger electroscope (which I had modified for the occasion) was provided with a gilded-copper disk condenser, and constant dry piles; that the rod which supported the gold leaf was insulated by a sheath of "pecite;" and finally, that the experiments were performed with sensibly constant temperatures that varied only between 28° and 24° C. during the last days of August and the first days of September, 1885. As may be seen, nothing is easier than to repeat this experiment, which is much simpler than the one that I devised in 1862. It is allowable for me to hope that when the majority of physicists shall have acknowledged its accuracy, it will no longer be necessary to seek new hypotheses as to the origin of atmospheric electricity. I lay stress upon this last point: "The preceding hypothesis aims only at the direct origin of atmospheric electricity," and not at the movements thereof.

In a work that Mr. Edlund, of the Royal Academy of Sciences of Stockholm, has recently published, and has had the goodness to send me, the author maintains, it is true, that the electricity of the earth rises into the atmosphere under the influence of the unipolar magnetism of our planet, but, on another hand, he acknowledges that electrical manifestations in the air, or the return of electricity toward the earth, are derived from the condensation of vapor, and especially from its conversion into water.

I much wish that meteorologists would pronounce decisively upon that delicate point—the prime cause of atmospheric electricity.

For my part, I am convinced that the immediate origin of the latter resides in the condensation of atmospheric vapor, and although, as regards ascending and descending movements, I do not entirely agree with Mr. Edlund, I am glad to see that the eminent Swedish physicist is entirely of the same opinion that I am as to the facts and experiments which seem to prove undeniably that the conversion of vapor into water, or its condensation, is really the direct cause of the development of atmospheric electricity.

* Read before the Royal Academy of Physical Sciences of Naples, Dec. 5, 1885.

CLERK MAXWELL'S ELECTRO-MAGNETIC THEORY OF LIGHT.*

By Miss J. M. CHAMBERS, B.Sc.

THE following is how I have supposed the "series of oppositely directed magnetizations and electromotive forces" of C. Maxwell's theory to arise. I do not in the smallest degree pretend to comprehend his mathematics, and it is only from his verbal explanation that I have formed the following conception of what his meaning is.

Suppose we have a straight linear conductor, A B, in which from some cause or another a quantity of electricity is continually bobbing up and down. We know

that the lines of magnetic force arising from these alternate up and down currents will be circles having the linear conductor for axis. Suppose we have a row of these conductors parallel to one another.

When the magnetic force lines cut the next conductor, *ba*, an electromotive force of opposite sign to that in A B will be engendered, in accordance with Lenz's law, and a current will ensue which will in its turn be surrounded by magnetic force lines. When the current in A B is reversed, the induced one in *a b* will be so too.

The action of *a b* on *a' b'* will be the same as that of A B on *a b*; and the same effects will be propagated along the whole line of molecules. We have here the electromotive forces and the magnetic forces acting in directions perpendicular both to one another and to the direction of propagation, O X, as the theory requires. Of course, this explanation would be for a plane-polarized ray.

It seems to me that this explanation presents to the non-mathematical mind, in a tangible form and in accordance with well-known electrical phenomena, what may be the manner of production of the "series of oppositely directed magnetizations and electromotive forces."

It is not necessary that the conductors should be linear; we may suppose them globular and touching one another, without interfering with the idea of the action above explained. We may, in fact, suppose them merely portions of the ether.

Perhaps it may be objected that my conductors are not circuits; but a current which keeps passing backward and forward from a condenser acts in precisely the same manner as a true current (see Art. 776, Maxwell, etc.), and why not also without the condenser?

Note.—Perhaps this idea is nothing new, and has occurred to others as well as to me. I have been told, however, that C. Maxwell himself would never precisely define the action by which he supposed light and electro-magnetic induction propagated.

* "A Simple Way of explaining Clerk Maxwell's Electro-Magnetic Theory of Light." From the *Phil. Mag.* for February.

KEPHYR.

KEPHYR (ke'fyr, gypy, kehapu, kapyyr) is prepared with cow's milk and a special ferment known as *Dispora caucasica*. This ferment was first described by E. Kern. It is a white, compact mass, elastic, covered with mucilage, resembling in aspect a cauliflower. It is found on mountains, below the snow line, on a certain kind of bush. The Russians call it gribki, signifying mushroom. The fungus (kephyr) consists of two parts—bacilli and yeast cells; but the principal part is composed of bacilli; these give it its mucilaginous appearance and its elasticity. According to Kern, each cell contains two round spores, whence the name he has conferred on it, *Dispora caucasica*. Kephyr is an effervescing drink, always greatly esteemed from time immemorial by the natives. It is prepared by mixing 30 grammes of the ferment with two glasses of milk from which the cream has been removed. The next morning it is poured into another receptacle, more milk without cream is added to it, and it is then bottled. It is kept at a temperature of 10° or 12° R. (54·5° to 59° F.) for twenty-four hours, and often shaken. Fermentation takes place more rapidly when milk sugar is added. Good kephyr is fluid, like oil, and pleasantly acid. The following table shows the comparative composition of kephyr and koumiss, and of milk—the basis of both—in one thousand parts:

	Milk.	Kephyr.	Koumiss.
Albumen	48	38	11·2
Butter	38	20	20·5
Lactose	41	20	22
Lactic acid	—	9	11·5
Alcohol	—	8	16·5
Water, salts	873	904·9	918·3

Kephyr is more agreeable than koumiss, and does not disturb the digestion; it is likewise cheaper. In order to succeed in preparing kephyr, the milk ought not to be too fat, nor the temperature too high nor too low during fermentation. Kephyr is an active analeptic; it is especially valuable in combination with iron for treating chlorosis, anæmia, and all affections of the respiratory organs. At the commencement of phthisis and dyspepsia, kephyr ought to be taken fasting—two glasses the first thing in the morning; later on, six, eight, or ten. Mandowski has found that it produces good effect in all kinds of dyspepsia, anæmia, catarrh of the stomach, chronic ulcer of the stomach, plumonary catarrh, phthisis and cancer. Pains in the stomach and vomiting were calmed in a few days by the use of kephyr. It stimulates the appetite, and is highly nutritious. In itself it forms sufficient sustenance for a few days.—*London Med. Record.*

CHOLESTERIN FATS.

SINCE it is probable that the material termed "lanolin," to which Professor Liebreich has recently directed attention, may become of some importance from a pharmaceutical point of view, it will be useful to place before our readers some account of its chemical nature and the sources from which it is obtainable. The grease of sheep's wool has long been the subject of attempted applications of an economic character, either by the production of soap or by the extraction of potash from the crude material obtained in cleansing wool for textile manufactures. Its true nature was first ascertained in 1868 by F. Hartmann, who showed that it contained a considerable amount of cholesterin. In fact, the grease of sheep's wool, though presenting some of the characters of ordinary fatty substances, is in its chemical nature quite different from them. The true fats, which were studied by Chevreul, and shown to be compounds of the trivalent alcohol glycerin with acids of what is termed the fatty series, are really a class of compound ethers, and they are substances which are not only chemically analogous, but also have a close connection with each other from a physiological point of view. The term fat, however, has ceased to have a very definite chemical meaning, since it may, in a physiological sense, be regarded as comprising other ethereal compounds, such as spermaceti and wax. In like manner, the fatty material of sheep's wool appears to consist, to a great extent, of a compound of cholesterin or of an isomeride of that substance with an acid of the fatty series. A later investigator of this subject, E. Schulze, confirmed Hartmann's results, and published methods for extracting the cholesterin constituent from the grease of sheep's wool. As cholesterin is very frequently met with in the animal organism, it might have been expected that the observations of Hartmann and Schulze would have received greater attention from physiological chemists; but with the exception of Berthelot's work, pointing to the probable existence of cholesterin ethers of fatty acids in the animal organism, this does not appear to have been the case until the subject was taken up by Professor Liebreich. On the supposition that cholesterin ethers of the nature of fats may be of greater importance in the animal economy than has yet been ascertained, he has taken the trouble to investigate this question and to give an account of such facts as bear upon it. In the endeavor to trace the presence in the animal organism of fatty compounds containing cholesterin, Professor Liebreich has taken advantage of a reaction discovered by Liebermann, which admits of the presence of that substance being detected. This consists in the production of a pink color, quickly changing to a decided blue when concentrated sulphuric acid is added to a solution in acetic anhydride of the fatty material to be tested. Great care is to be exercised in adding the sulphuric acid so as not to have too much, which would obscure the reaction.

By means of this test, Professor Liebreich has examined a number of fatty materials, and he has ascertained that while cholesterin fats, in which no trace of free cholesterin could be suspected, invariably gave the reaction above described with perfect distinctness, glycerin fats, on the contrary, did not show the reaction at all. Various other substances, such as beeswax, spermaceti, lecithine, and protagon, also gave negative results. The first experiments made by Professor Liebreich were with animal tissues analogous to horn, such as tortoise-shell, whalebone, human epidermis, hair, the beak of the jay, feathers of the goose, hen, turkey, and pigeon, bristles of the hedgehog and porcupine, the hoof and warty excrescences on the leg of the horse, and the horny substance of the sheep's foot. In all these tissues it was possible to trace the presence of cholesterin fat by means of the above mentioned reaction, after the fat had been extracted by chloroform.

As a further means of recognition, the peculiarity of cholesterin fat in absorbing a very large proportion of water was taken advantage of. To this character Professor Liebreich has applied the name of "lanozation." It is shown in a very marked manner by the fatty material obtained from sheep's wool; and on testing the fats extracted from the above mentioned materials, it was possible in almost all instances to ascertain that they possessed this capacity for the mechanical assimilation of water. It was also ascertained that a mixture of glycerin fats and cholesterin did not lanolize. Fat obtained from superficial fascia was not found to show much, if any, reaction indicative of the presence of cholesterin; but, on the other hand, fat obtained from a kidney and from the liver, and the fat from the blood of a rabbit, gave very decided indications of its presence. The question whether it originates from the blood or belongs to the kidneys and other organs must be left for future investigation.

Professor Liebreich then proceeded to examine the question whether cholesterin fats belong to the various tissues as such, or whether they are produced by glandular secretions; and he is of opinion that in the case of birds the liquid secreted by the glands does not so much serve to oil the feathers as to free them from too great a profusion of fat, or at least to spread the fat evenly over their surface. In birds that have no coccygeal gland, such as the parrot and the fan-tailed pigeon, the feathers have a far less shining appearance; but on trial the feathers of the fan-tailed pigeon were found to contain a small amount of cholesterin fat, and it was inferred that birds without any coccygeal gland must be able to secrete sufficient fat from the feathers, and that in fact it is formed simultaneously with horny tissue.

In regard to the commonly received opinion that the fat contained in hairs is secreted from the sebaceous glands, these and the sudoriferous glands are in the case of sheep so numerous that these animals offer little aid in deciding whether intracellular fat ever occurs alone. But cholesterin fat was also found in the bristles of pigs and the prickles of the hedgehog, though both animals possess sebaceous glands only in a stunted condition. The sloth has not any sebaceous glands, but the hairs from this animal gave the cholesterin reaction. While therefore it is probable that the sebaceous glands furnish fat to keep the hairs supple, this fat is very different from that present in and formed by horny tissue. The fat of the coccygeal gland of the goose gives a very slight cholesterin reaction, and the fat of the superficial fascia surrounding the gland gives none, while in the fat obtained from the feathers the reaction distinctly indicates the presence of cholesterin fat. Abundance of it was also found in the hoof of the horse and in the warty excrescence on the leg of the horse, although there are here no glands to secrete fat. In the penguin an apparent exception is met with, and in its horny tissue there seems to be some other fat.

According to the view put forward by Virchow, the fat of the animal organism may be either the normal contents of cells or only transitory, as, for instance, in the intestinal epithelium cells, or it may be present, as in the case of milk, after the destruction of the cells. Cholesterin fat may be of this kind, and analogous in the mode of its formation to butter, if originating from the cells of horny tissue, which are destined to be exfoliated. There seems to be good reason for regarding it as present in many parts of the bodies of animals, and it is probable that it may be obtained from other sources besides the wool of sheep. It is mainly from the pharmacological point of view that the investigation by Professor Liebreich has been carried out, since he was of opinion that the peculiar characters of the cholesterin fats would render them available for the purposes of medical treatment by ointments, etc., in cases where there are well founded objections to the use of any of the hydrocarbon fats, such as vaseline and the various kinds of paraffin. One peculiarity of cholesterin fat is the ease with which it can be rubbed into the skin, and this ready absorption may be connected with the circumstance that it originates from horny tissue. Another important point is that cholesterin fat (of which the lanolin prepared from the grease of sheep's wool is a type) is perfectly neutral, and as it is very difficult to saponify, even with an alcoholic solution of caustic alkali, it may be expected that it will not be so liable to become rancid as glycerin fats.—*Pharm. Journal.*

THE DENSITY OF SATURN'S RING.

M. POINCARE supplies a short note on the stability of Saturn's ring in the November number of the *Bulletin Astronomique.* Laplace had shown that the ring could only be stable if it were divided into several concentric rings revolving at different speeds. M. Tisserand had confirmed this result, and had recognized that a single ring must, in order to exist, possess a much higher density than the planet, and had calculated the maximum breadth of each elementary ring in terms of its density and mean radius. M. Poincare has carried this investigation a step further, and shown that if the density of a ring be less than a certain amount, it will, under the influence of the slightest perturbation, no longer break up into a number of narrower rings, but into a great number of satellites, and that if the rings be fluid and turn each as a single piece, the density of the inner ring must be at least $\frac{1}{8}$, and of the outer ring $\frac{1}{18}$ that of the planet. For a ring of very small satellites (not for a fluid-ring, as M. Poincare erroneously states), Maxwell has shown the condition to be that the density should not *exceed* $\frac{1}{300}$ part of that of Saturn.

We do not at present know the actual density of the ring from observation sufficiently accurately to make therefrom any certain inference as to its physical condition. Bessel's determination from the movement of the peri-saturnium of the orbit of Titan gave the reciprocal of the mass of the ring as compared with that of Saturn as 118, which, since the volume of the ring—adopting Bond's value of 40 miles for its thickness—is about $\frac{1}{405}$ that of the planet, would make its density about 3·4 times greater than the planet's. Bessel's value is, however, clearly too great, as he neglected the influence of the equatorial protuberance of Saturn on the movement of the apsides. Meyer's determination of the secular variation of the line of apsides of Titan, viz., $d\dot{\pi} = 1726{\cdot}5''$, gives the reciprocal of the mass of the ring as 26,700, but from all the six brighter satellites as 1,960; the latter value closely agreeing with Tisserand's. It does not, however, seem to have been noticed that even the smallest value for the mass considerably exceeds the highest permissible in accordance with Maxwell's result, since that would make the mass of the rings only $\frac{1}{150000}$ part of the planet's, an amount we cannot hope to detect with our present resources.—*Nature.*

THE RELATION BETWEEN THE PHYSIOLOGICAL AND THERAPEUTIC EFFECTS OF REMEDIES.

THIS relation is generally very imperfectly understood. It is well known that many of our therapeutic agents in common use produce entirely different and even opposite results according as they are given in large or small doses. It is usually supposed that this is due to their having different properties corresponding to the quantity used. It requires but little reflection, however, to see that this view is absurd. Quality does not depend on the quantity. No substance has ever yet been discovered which is not capable of exhibiting all the properties it possesses, in the most minute as well as in the largest quantity. Yet the fact remains that drugs capable, when used in sufficient amount, of producing injurious and even fatal consequences will, in medicinal doses, have an entirely opposite effect. The explanation of the various phenomena thus shown lies in the fact that medicines possess no curative powers whatever, excepting that they are able to arouse the vitality of the tissues with which they come in contact, this vitality being itself the source of all the remedial qualities drugs are supposed to possess. How otherwise can we account for the healing properties of substances the mere contact of which is sufficient to cause the death of the tissues with which they come in contact? Strong solutions of the sulphate of zinc, chloride of zinc, nitrate of silver, and many other similar remedies, are capable of causing inflammation of the urethra and other membranes; they are capable of producing the death even of the tissues with which they are brought in contact, yet when applied in lotions of suitable strength will cure urethritis, as well as inflammations of other mucous membranes, such as those of the eye, vagina, etc. It is nonsensical to suppose that the remedial effects herein exhibited depend on a difference in the qualities of the drugs, according to the amount used. Tested in large or small quantity, their properties will be found to be the same; but in a solution of proper strength the injurious effect of the drug simply excites the vitality of the part, which overcomes the poisonous properties, that in sufficient strength would produce injury or death. There is not a drug used by the medical profession which will not, when used in excessive quantity, cause poisonous symptoms; and the immediate effect is injurious, whether the dose is large or small, the difference being that in one case the vitality of the tissues is excited or stimulated, while in the other it is overcome. The bitter vegetable tonics afford us an example of the fact that therapeutic agents, which are able in poison ous doses to cause morbid symptoms, will, when properly used, cure the disease thus set up. Gentian, calumba, cinchona, and the other remedies belonging to the same class as these, will relieve dyspepsia, yet, in excessive quantity, or when too long continued, they will produce the same disease. Arsenic, corrosive sublimate, nitrate of silver, together with many other metallic salts of like nature, such as the salts of zinc and copper, will, in poisonous quantities, cause severe pain in the stomach. They are also curative of gastralgia in small doses. The saline purgatives, calomel, ipecac, rhubarb, colocynth, podophyllin, aloes, and castor oil, will, in sufficient quantity, cause diarrhœa and dysentery, yet, in medicinal doses, they will cure these diseases.

Arsenic, in excessive doses, causes various inflammatory diseases of the skin, but is nevertheless curative in diseases of the same nature, such as chronic eczema and chronic psoriasis. Bromide of potash, chloral, hydrocyanic acid, and chloroform are among the most nauseous of remedies, yet in small doses they are almost specific in their power of allaying nausea and vomiting.

Sulphate of zinc, tartar emetic, and ipecac are other examples of the curative power of emetic remedies to relieve the irritable condition of the stomach of which nausea is the symptom.

Turpentine, balsam of copaiba, oil of cubebs, savine, capiscum, cantharides, buchu, and other remedies possessing similar properties will, in poisonous doses, cause inflammation of the pelvic viscera, yet these inflammations form their stage of their therapeutic action.

Counter irritation is remedial only by its power of calling forth the vitality of the part to which its influence is exerted. The various organs are so intimately connected by the nervous system, that an effect cannot be produced on one part without modifying the others in greater or less degree. This explains the fact that extensive burns may be followed by inflammation of internal organs; and the spread of inflammation from one eye to the other is due to the same nervous influence. The connection between parts supplied from the same nervous center is especially close, and any irritation applied to one is quickly reflected to the other. In this way inflammation of an organ may be relieved by a remedy applied to an adjacent part. The reflex impression on the morbid tissues is, of course, an injurious one, but it develops their vitality and is in this way curative. The close nervous connection of tissues explains the power of anodyne remedies to relieve internal pain when applied to the skin, as in the case of rheumatism, where soothing liniments externally applied will allay the pain seated in the joints.

Purgatives, diuretics, diaphoretics, and emetics may be classed together as eliminative medicines, whose effect is nearly the same, differing only as to parts on which they act. They all produce relaxation of the blood vessels, and this state of the vessels characterizes the affections in which they prove remedial. This is very obviously the case in diseases characterized by dropsy. In most of such troubles the vessels are in a relaxed condition, and the purgative remedies usually given produce the same state, but this slight relaxation is followed by a reaction in which the vessels are stimulated, the effused serum absorbed and the dropsy disappears with its cause—the atonic condition of the vessels. The cause of dropsy is supposed to be the increased pressure of the blood, but this view is shown to be erroneous, by the fact that there is not in general an unusual blood pressure in the diseases of which dropsy is a symptom. The vessels are relaxed, and allow the blood to pass through them in the same way that water leaks from a barrel whose staves are shrunken. These medicines are used in inflammations and fevers, in both of which there is a weakened, dilated condition of the vessels. The pathology of both these affections is, I believe, the same.

They always accompany each other, and there is good reason to suppose that fever is never anything more than the sympathetic disturbance of an inflammation. This is certainly true of the fever which accompanies those inflammations caused by wounds; and not only does fever never occur without its accompanying inflammation, but the state of the blood vessels is nearly the same in both. The only difference between the two is that the one is a local disease, set up at the seat of injury, while the other is a similar condition, less intense, but more general, in which all the vessels share in the injurious effect produced on a few of them. The nervous centers and sympathetic plexuses which supply the vessels being intimately associated, any disturbance of one part of the vascular system is quickly conveyed to the whole of it, on the same principle that burns of the skin cause inflammation of the internal organs. The increased activity of the processes of nutrition which take place in fevers is owing to the fact that the dilated vessels permit an unusual supply of blood to the organs whose functions are temporarily stimulated. It is supposed that eliminative agents relieve febrile conditions by diminishing the amount of the watery constituents of the blood, thus removing the tension of the vessels. If this were true, we must assume that there is more blood in the body in fevers than in a state of health—a fact which has never been proved and is without probability. Furthermore, the vascular condition may be relieved by remedies which do not diminish the quantity of serum, but which produce an atonic, relaxed condition of the vessels. Emetics belong to this class of medicines. They, as well as all the other eliminatives, by their injurious action on the vascular system, excite in it a reaction which not only overcomes the poisonous influence of the drugs, but also relieves the diseased condition to which the febrile symptoms are due.

Digitalis is a cardiac poison, yet, in medicinal doses, it gives relief in diseases characterized by weak action of the heart. Strychnia causes symptoms very similar to those of tetanus when given in lethal doses, but when properly used is remedial in that affection. We will now consider a class of remedies which, when given in excessive doses, have a distinctly poisonous action on the nervous system. Opium, chloroform, ether, bromide of potash, chloral, etc., are capable of causing death or, as in the case of bromide of potash, symptoms of a serious character.

They act primarily on the nervous system, and affect other parts only secondarily. They are curative in the diseases of which the essential feature is nerve weakness. Pain and spasm, as well as other forms of perverted function of the nerves and their ganglia, indicate an abnormal condition, a condition of weakness or loss of tone, yet it is in this form of disease that the various sedative, narcotic, and anti-spasmodic remedies give temporary and sometimes permanent relief. The caustic substances which are used to detroy malignant growths and gangrenous or sloughing tissues, while destroying some of the healthy tissues near the diseased mass, arouse their vital force, and in this way produce all the healing effect they are capable of.

Remedies which are irritant to the bronchial mucous membrane, such as ammonia and turpentine, and which are able, in sufficient amount, to set up inflammation of the respiratory mucous membrane, are successfully used in the treatment of bronchitis and pneumonia.

Many more examples might be quoted of the fact that medicines possess no healing qualities in themselves, other than their capacity to inflict injury, and in sufficient quantity death, of the tissues with which they come in contact, in virtue of which they are able to excite the vital powers to action, when given in doses too small to produce permanent damage.

The instances I have mentioned are, however, enough, I think, to prove that the principle on which they exert their remedial effects is the one which governs the action of nearly all the therapeutic agents in use. I say nearly all, because there are a few remedies which act by assisting the function of the organ on which their curative power is supposed to act. These afford only temporary relief, and in the end simply aggravate the trouble for which they are given. Pepsin is an example of this class of medicines; by supplying a deficiency of this constituent of the gastric fluid, it gives relief for a time, but will not produce any permanently good results. It is the same with the use of alkalies to overcome acidity of the stomach; the relief given is only temporary, while small doses of the mineral acids produce a permanent cure. In the same way a deficiency in the acid of the digestive fluid is cured, not by giving hydrochloric acid, but by small doses of the alkalies. The skin is excited to a healthy condition, not by a tepid bath, which, by its warmth, assists the natural powers, but by a cold bath, whose primary injurious effect is followed by a reaction which stimulates vital action.

Who has not felt the enlivening influence of a frosty autumnal morning, or deplored the enervating effect of a sultry summer day? Yet heat is the supporter of life, while excessive cold induces a drowsiness which is merged in the sleep of death. The principle which governs the action of all remedies regulates the growth and development of the physical and mental qualities of men. Hard work, want, and adversity are destructive in their nature and are capable of producing the worst consequences, yet it is through struggling with them that the greatest men have had perfected in them those qualities which have gained for them the applause of the world. Man is "made perfect through suffering," rather than through ease and enjoyment.

Our knowledge of the physiological effects of drugs is very imperfect; it is therefore impossible to see the relation between the poisonous and medicinal properties of remedies in all cases, but I believe that wherever this relation can be clearly traced, it can be shown to be governed by the same principle which underlies the remedial powers of the therapeutic agents I have mentioned.

It may be said that drugs are not to be judged by their poisonous properties. But in ascertaining the nature of a remedy, it is best shown when given in such a manner and under such conditions as shall reveal the

whole range of its influence on every condition, symptom, or disease of the body. It may be argued that if the idea I have advocated be true, if whatever causes a disease is capable of curing it, the causes of disease should in themselves be sufficient to effect a cure. To this I would say that this is actually the case. Without going over the many instances I have already mentioned, in which poisonous remedies simply call forth the vitality of the tissues, and are themselves the agents through which the powers of nature are excited to overcome the injury inflicted by them, it will be sufficient to mention the following facts, which show that all injurious agents carry within themselves their own remedy. When there is bleeding from a small artery, the loss of blood stops the hemorrhage.

An ordinary wound heals without treatment, and the energy thus put forth is obviously greater than that required to maintain the normal process of nutrition in the injured part. The soreness of the hands caused by hard muscular work is relieved by a continuance of the cause of the trouble. I have not spoken of drugs possessing any healing power in poisonous doses, so I am under no necessity of showing that the injurious effects of medicines may be cured by a contimation of their use. It is a fact, however, that the lethal effect of poisons are often relieved by a poison possessing similar properties to the one which has been taken. The corrosive poisons may, when swallowed, be rendered harmless by promptly administering an emetic of the sulphate of zinc or copper, and even narcotics may be neutralized by other narcotic drugs, given in stimulant doses. I am aware that the theory I have put forth here is somewhat like the principle on which homeopathy is founded. While there is considerable truth in homeopathic ideas of therapeutics, however, it is obscured by so much that is erroreous that the really valuable points in their theory do not receive the attention they deserve. It is plain that the thousandth or millionth of a grain of calomel can have no appreciable effect on the intestine, though it is undoubtedly the case that, when used in small doses, it is capable of relieving the diarrhœa of children. The same holds good of many other homeopathic remedies, and the tendency of homeopathy is now toward the substantial doses of the regular school of medicine. The truths which have brought legitimate medicine to so high a state of perfection as it now enjoys have been arrived at through long ages of patient research and careful observation; and formed, as they are, on actual experience, no theory can alter them. There can be no doubt that drugs capable of producing certain symptoms in poisonous doses are able, when rightly used, to relieve them, but it is a rather vague and uncertain method to depend on such phenomena as a guide to the treatment of disease. A better way is to observe the special action medicinal substances have on certain tissues, and to employ the remedy in diseases affecting such tissues.

In the development of the embryo there are differentiated from the original protoplasmic cells three types of tissues, each of which is again subdivided into various other kinds, according to the function required of them. These are fibrous tissue, consisting of connective tissue, muscle, etc.; nervous tissue, with its varieties of sympathetic and cerebro-spinal; and epithelial tissue, consisting of the skin, mucous, serous, and endothelial membranes. Eliminative remedies affect especially the fibrous tissues. They act on the vessels in such a manner as to relax them, and to produce relaxation of the muscles as well as the fibrous tissue which enters into the composition of the vessels. The various narcotic and sedative remedies have their primary action on the nerves and their ganglia. The bitter and astringent tonics exert their action chiefly on the epithelial tissues. All these remedies have a special poisonous action on the tissues, each one affecting a certain part of the system, and having the capacity to relieve morbid conditions, having their seat in the part on which they act. The principles governing the therapeutic action of remedies and their relation to the diseases which they relieve may be summed up as follows:

All medicines are poisonous.

All are capable of causing two distinct effects: the one, in which the injurious nature of the remedy arouses the vitality of the affected part, and the other in which the vitality is overcome by the poisonous properties of the drug.

Whatever causes a morbid condition of a tissue is capable in proper doses of relieving similar conditions of such tissues.

F. R. Hays, M.D.

Bath on the Hudson, N. Y., March, 1886.

KOBELKOFF, THE "TRUNCATE ARTIST."

It is related that, while two cripples were conversing, one said to the other: "You are lucky, for you are lamer than I, and so they give you much more." It is unfortunately true that among the poor who have lost one or several limbs, and who have no other resources than begging, the most impotent and most monstrous are the ones that excite most pity and public charity, and these, in the eyes of their companions, have most luck. An individual who is at this moment exhibiting at Paris under the name of the "Truncate Artist," and who lacks not only the two legs, but also the two arms, utilizes his infirmity in a very different way. This man, in fact, performs in public a series of acts and feats of dexterity, and even some acrobatic ones, which the majority of the spectators would have to employ both hands and feet to repeat. Farther along, we shall describe these in detail.

The Truncate Artist has a stout, muscular body and a very short neck, and appears to be strong and hardy. In the little pamphlet that he sells to the public he states that his age is 34 years, and that he was born at Troizk, Siberia. His mother had had thirteen children before him, all of them normally formed. He says that he enjoys excellent health and has never been sick. He has been traveling and exhibiting himself as a curiosity since 1870. He has traveled through Russia, Sweden, Norway, Germany, Austria, and Italy. He married in 1876, in Austria, and has now five children—five well-formed boys. His name is Nicolai Wassiliewitsch Kobelkoff. His posters read: "The wonderful phenomenon; the greatest curiosity of the age."

Let us add that he looks as if he were well content with his lot. He has a smiling countenance, and, at his exhibitions, while waiting until there are enough spectators present, he laughs and talks with his children, who are pretty little blonds, or speaks a few pleasant words to those coming in. His face shows frankness and good nature.

From an anatomical point of view, the Truncate Artist has been examined several times by medical commissions, especially at Lyons a few months ago, where he stayed for some little time.

He has two rudiments of thighs, in the right one of which the femur is about six inches in length, and in the other is a little longer, say from eight to ten inches. The left arm is entirely wanting; a rounded bone, representing the head of the humerus, alone occupies the articulation of the shoulder.

The right arm is represented by a sort of conical stump, 8 inches in length, composed of a part of the humerus covered with well developed muscles. We especially distinguish the deltoid, the large muscle of the shoulder and upper part of the arm. The *teres major*, and all the muscles that are attached to the sides of the breast or to the scapula, act upon the head of the humerus and upon the first portion of the latter;

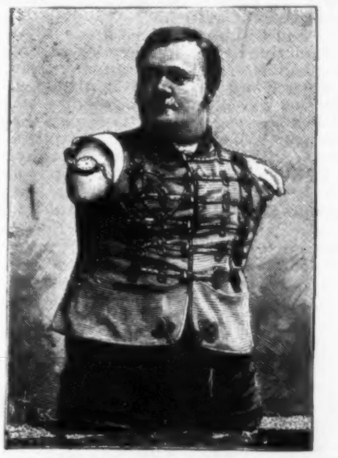


Fig. 2.—NICOLAI WASSILIEWITSCH KOBELKOFF.

but the muscles which, in a perfect man, start from the latter region and act upon the hand or forearm, such as the biceps, brachial, and tricips, are atrophied, and soldered by their extremity. They form the apex of the conical stump, and seem to have an influence upon its mobility. This rudimentary arm the "artist" utilizes in a most ingenious way by putting it to his cheek, chin, and body in order to perform that series of exercises which astonish the spectators. These exercises are as follows: Being placed upon a chair near a table upon which various objects are lying, he takes a penholder, fixes it between his arm and cheek, dips the pen into an inkstand, and then writes the name of each spectator upon a sheet of paper and gives it to him as a keepsake. At our request, he wrote the lines shown in Fig. 3 for the sake of our readers. As may be seen, his writing is very regular, with beautiful curves in the capitals, and a flourish to his signature worthy of a writing master.

He cuts paper with a pair of scissors; he takes a bottle of water, uncorks it, pours some of the liquid into a glass, places the latter on his arm, and carries it to his lips; he takes a fork, picks up pieces of bread from a plate and carries them to his mouth; he makes believe eat soup with a spoon; he takes his watch out of a side pocket, opens the case by pressing the button, looks at the time, and puts the watch back into his pocket; and he threads a needle. To do the latter, he takes the needle in his mouth and sticks it into a cushion, then holds the thread between his lips and passes it through the eye of the needle, and, holding the extremity of the thread with his arm, turns the cushion around, seizes the thread again with his lips, and pulls it way through.

He performs an elementary calculation upon a blackboard; he makes a drawing on a piece of paper with a pencil or crayon; and he takes a pistol, cocks it, aims it at a lighted candle, fires, and extinguishes the flame.

He jumps from a chair to the floor; and then through motions of the spinal column makes a series of leaps that somewhat resemble the efforts made by those engaged in a bag race. He also performs a sort of somersault; and, finally, as an exhibition of strength, he carries a man of medium stature standing erect upon his rudimentary arm.

Such are the exercises of the Truncate Artist.

The history of human monsters has already recorded a certain number of examples of children born without limbs. Teratologists place them in the class of monstrosities by defect, and in the category of ectromeles, that is to say, of individuals with abortive limbs. Saint-Hilaire, in his treatise on teratology, cites several cases of them. Only last year the medical journals noticed the birth, in Spain, of a female child which had neither legs nor arms, but was very lively and had a good constitution.

In Brittany, in 1875, among the beggars that stood along the two sides of a road ending at Saint-Pol-de-Leon, we saw a little girl who was destitute of limbs, and who was lying upon a little straw. Her father and mother were kneeling on each side, counting their beads and mumbling prayers. Sous dropped in abundance into the bowl placed near the little one, for, according to the belief of the country, women, by giving alms to this child, preserved their own future ones from a like infirmity.

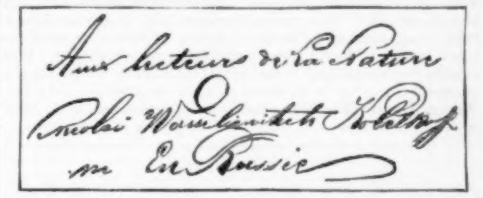


Fig. 3.—SPECIMEN OF KOBELKOFF'S CHIROGRAPHY.

A certain number of truncate men have exhibited themselves in public, and, through their dexterity, have deserved to have their names transmitted to posterity. Thus, an English writer of the 16th century, Stow by name, tells us that in 1581 he saw a Dutchman in London who had two handless stumps of arms which he skillfully used for throwing up a cup and catching it again. He likewise dexterously shot an arrow at a mark, fenced, and used an ax. Stow adds that this man daily drank two pints of the best beer that he could procure.

The famous Matthew Buchinger, who was born at Anspach in 1674, came into the world minus hands and legs. A contemporary author says of him that instead of arms he had two excrescences that resembled the fins of a fish rather than human arms, but which he used with much skill. He wrote very legibly, ate with a fork or spoon, drank out of a goblet, etc. A portrait of this monster is preserved in the British Museum. Buchinger, notwithstanding his deformity, was married four times.

In the middle of the last century there was exhibited in France, especially at the Saint-Germain Fair, a so-called Venetian girl, who, although her arms were but stumps, threaded a very fine needle, knotted the thread with her tongue, sewed, spun, knitted, and cut all sorts of stuff with a pair of scissors. She even played on the violin.

Fifty years ago there was a truncate man in England who was famous, although he did not exhibit in public. He was a young lord, the possessor of an immense fortune, and was born without legs and arms. He had received an excellent education, was endowed with much genius, loved society, and took part in all the fetes and receptions of the English aristocracy. In the parlor, he was placed upon a very high stool in a sort of basket containing a cushion, upon which he stood erect. Despite his deformity, this young man was passionately fond of horses and horseback riding. He was placed upon a saddle of peculiar form to which he was fastened by means of a strap. The reins were fixed to his shoulders, and in this way he succeeded in directing his steed.

Truncate men, then, are not only curious examples of those singular anomalies that are sometimes met with in the human species, but they also show how individuals of strength, labor, patience, and ingenuity succeed in making up for organs that are wanting.—*La Nature.*

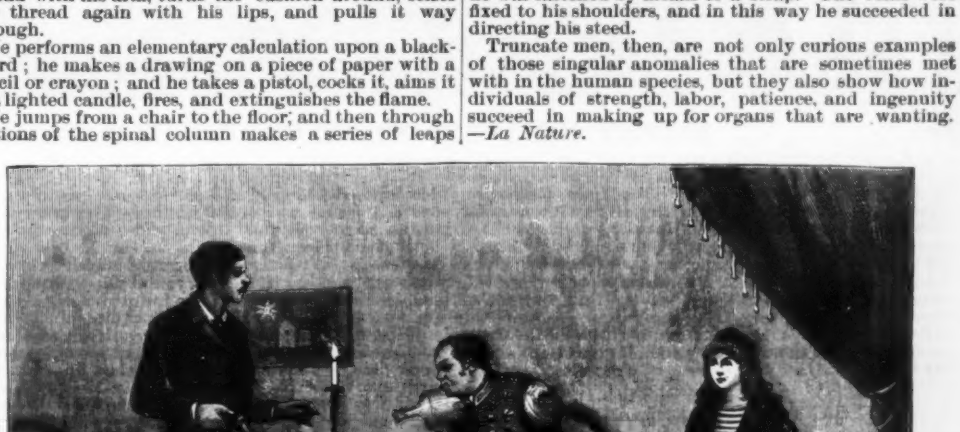
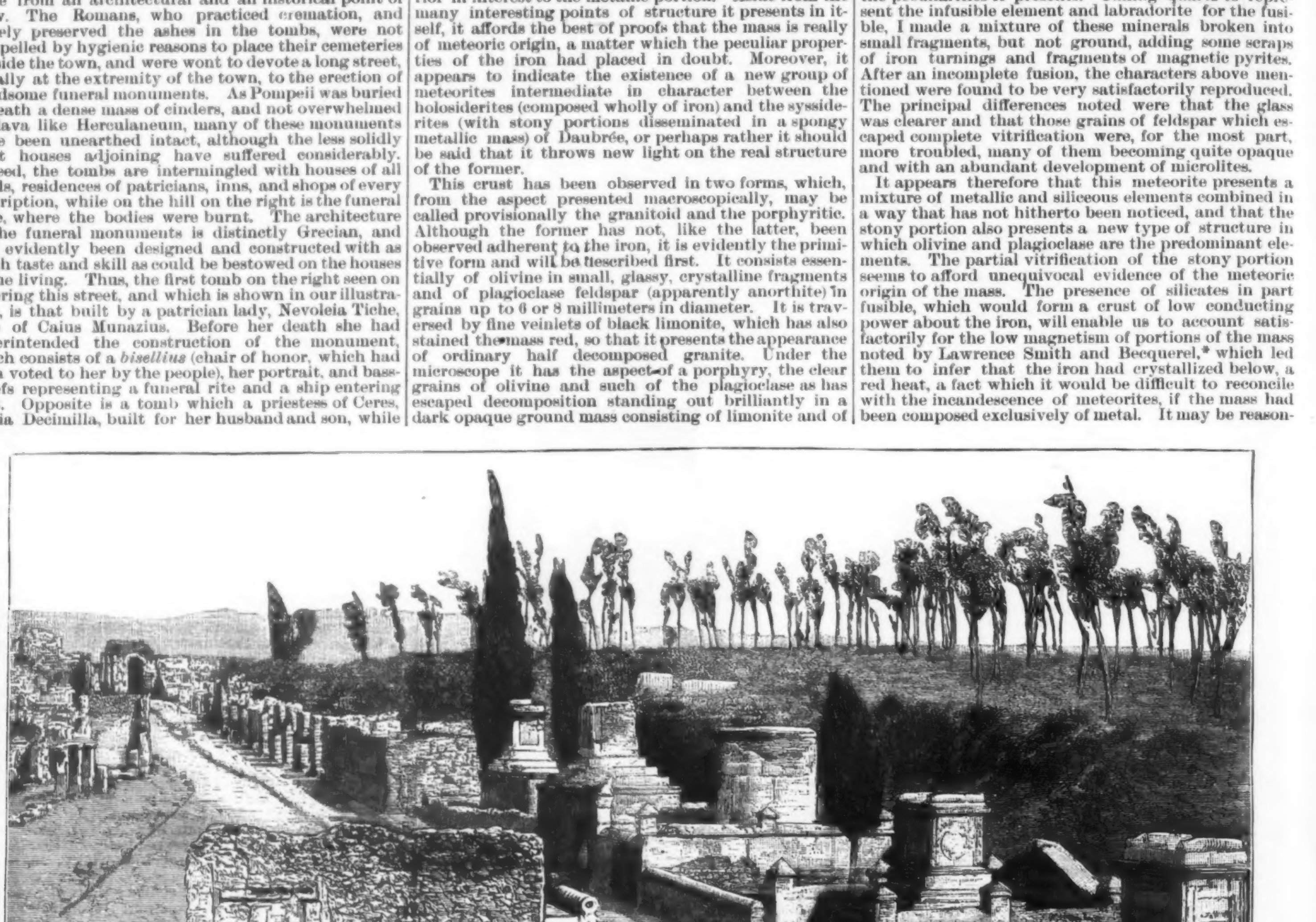


Fig. 1.—PERFORMANCES OF THE TRUNCATE ARTIST.

THE STREET OF THE TOMBS, POMPEII.

The Street of the Tombs is one of the most interesting features of Pompeii, as it is in an exceedingly good state of preservation, and teems with monuments interesting alike from an architectural and an historical point of view. The Romans, who practiced cremation, and merely preserved the ashes in the tombs, were not compelled by hygienic reasons to place their cemeteries outside the town, and were wont to devote a long street, usually at the extremity of the town, to the erection of handsome funeral monuments. As Pompeii was buried beneath a dense mass of cinders, and not overwhelmed by lava like Herculaneum, many of these monuments have been unearthed intact, although the less solidly built houses adjoining have suffered considerably. Indeed, the tombs are intermingled with houses of all kinds, residences of patricians, inns, and shops of every description, while on the hill on the right is the funeral pyre, where the bodies were burnt. The architecture of the funeral monuments is distinctly Grecian, and had evidently been designed and constructed with as much taste and skill as could be bestowed on the houses of the living. Thus, the first tomb on the right seen on entering this street, and which is shown in our illustration, is that built by a patrician lady, Nevoleia Tiche, wife of Caius Munazius. Before her death she had superintended the construction of the monument, which consists of a *bisellius* (chair of honor, which had been voted to her by the people), her portrait, and bass-reliefs representing a funeral rite and a ship entering port. Opposite is a tomb which a priestess of Ceres, Alleia Decimilla, built for her husband and son, while the next tomb on the right is that of Caius Calventius Quietus, one of the most wealthy and generous inhabitants of the town, and who was also voted a *bisellius* for his liberality. The neighboring tomb is in memory of Quintus Amphictus, and is remarkable for the bass-reliefs which surround it, and which represent hunting scenes and gladiatorial combats, both on foot and on horseback, with very interesting inscriptions. Our view is from one of the latest photographs of the street, and shows the monuments which had been unearthed at the close of last year.—*London Graphic.*



RECENT EXCAVATIONS AT POMPEII, ITALY.—THE STREET OF TOMBS.

THE SANTA CATHARINA METEORITE.

By Orville A. Derby.

Having recently undertaken, in company with Mr. Luiz Gonzaga de Campos, an examination of the Brazilian meteorites preserved in the National Museum of Rio de Janeiro, in which that gentleman has taken charge of the chemical and I of the physical part of the work, I have had occasion to make the following observations on the somewhat famous Santa Catharina meteorite, which seem to be of sufficient importance to warrant publication in advance of the more extended general memoir that we are now preparing.

M. Daubrée, who has so thoroughly studied the metallic portion of this meteorite, mentions an ocherous crust in some of the specimens* which he took to be of secondary and terrestrial origin, and to be composed of a mass of limonite resulting from the oxidation of the iron, together with imprisoned fragments of the disintegrated granite on which the mass was stated to have rested. Misled by this conclusion (a very natural one if, as is to be presumed, the crust on the specimens examined was partially decomposed), he devoted all his attention to the metallic elements, with the brilliant results that are so well known. This crust, however, when examined on well preserved specimens, proves to be an essential part of the meteorite, in nothing inferior in interest to the metallic portion. Aside from the many interesting points of structure it presents in itself, it affords the best of proofs that the mass is really of meteoric origin, a matter which the peculiar properties of the iron had placed in doubt. Moreover, it appears to indicate the existence of a new group of meteorites intermediate in character between the holosiderites (composed wholly of iron) and the syssiderites (with stony portions disseminated in a spongy metallic mass) of Daubrée, or perhaps rather it should be said that it throws new light on the real structure of the former.

This crust has been observed in two forms, which, from the aspect presented macroscopically, may be called provisionally the granitoid and the porphyritic. Although the former has not, like the latter, been observed adherent to the iron, it is evidently the primitive form and will be described first. It consists essentially of olivine in small, glassy, crystalline fragments and of plagioclase feldspar (apparently anorthite) in grains up to 6 or 8 millimeters in diameter. It is traversed by fine veinlets of black limonite, which has also stained the mass red, so that it presents the appearance of ordinary half decomposed granite. Under the microscope it has the aspect of a porphyry, the clear grains of olivine and such of the plagioclase as has escaped decomposition standing out brilliantly in a dark opaque ground mass consisting of limonite and of decomposed feldspar, and perhaps also of other decomposed silicates and of an original glassy ground mass, if the rock contained them. The olivine grains are beautifully clear, but much fractured, showing along the cracks a yellow discoloration which occasionally presents a beautiful botryoidal appearance. The specimens of this rock have unfortunately been hammer-dressed, so that they show nothing of the original surface. They represent, however, a thickness of several centimeters at least. No grains of metallic iron have thus far been detected in them, but as points of the rock exert a slight influence on the magnetic needle, their presence is suspected. Minute grains that appear to be magnetite have been separated with the magnet, but have not yet been examined. The porphyritic rock forms a crust, 1 to 2 centimeters thick, completely enveloping an oblong rounded mass of iron, 18 centimeters long and 10 centimeters in diameter. This crust scales off readily, taking always a portion of the iron with it. Small fragments of iron are also scattered through it. The surface of this crust being somewhat decomposed and ocherous, the appearance of the entire mass, which may be called a meteoric individual, as it has evidently not been broken from a larger mass since the fall, is that of the concretionary masses of limonite common in decomposed granite and elsewhere. This is a true porphyry, consisting of grains of olivine with rare fragments of plagioclase scattered in a dark glassy ground mass which can only with difficulty be rendered transparent, when it presents a light reddish color. The mass is somewhat scoriaceous from the presence of numerous rounded cavities, and the glass presents a fluidal structure. The feldspar has much the same appearance as in the granitoid form, that is to say, a clear nucleus surrounded by an opaque portion. The nucleus, however, is not troubled as in that rock, and the opacity is, in this case, evidently due to vitrification of the margins of the grain, and not to decomposition, as in the case of the granitic rock.

In order to verify the idea that was at once suggested, that this porphyritic rock was the result of the partial fusion of the granitoid, I attempted to reproduce the peculiarities it presents. Taking quartz to represent the infusible element and labradorite for the fusible, I made a mixture of these minerals broken into small fragments, but not ground, adding some scraps of iron turnings and fragments of magnetic pyrites. After an incomplete fusion, the characters above mentioned were found to be very satisfactorily reproduced. The principal differences noted were that the glass was clearer and that those grains of feldspar which escaped complete vitrification were, for the most part, more troubled, many of them becoming quite opaque and with an abundant development of microlites.

It appears therefore that this meteorite presents a mixture of metallic and siliceous elements combined in a way that has not hitherto been noticed, and that the stony portion also presents a new type of structure in which olivine and plagioclase are the predominant elements. The partial vitrification of the stony portion seems to afford unequivocal evidence of the meteoric origin of the mass. The presence of silicates in part fusible, which would form a crust of low conducting power about the iron, will enable us to account satisfactorily for the low magnetism of portions of the mass noted by Lawrence Smith and Becquerel,* which led them to infer that the iron had crystallized below, a red heat, a fact which it would be difficult to reconcile with the incandescence of meteorites, if the mass had been composed exclusively of metal. It may be reasonably inferred that different portions of the mass will be found to vary in magnetic properties. It is hoped that material for investigating this and other questions may be obtained in a visit which Mr. Campos will shortly make to the place of fall for the purpose of collecting facts for the full history of this interesting meteorite.

The observations here presented suggest the suspicion that other large iron meteorites may present something analogous, and it is hoped that an opportunity may shortly be afforded for examining the famous Bemdego meteorite, which, judging from the descriptions of Mornay and of Spix, and Martius, contains stony portions. The former mentions a crust on the lower portion, and the latter state that it rested on a mass of granite fragments, which, in view of the above facts, may be suspected to have belonged to it. Both mention masses of quartz embedded in the iron, which are most probably of olivine.—*Amer. Jour. of Science.*

* Comptes Rendus, vol. lxxxiv. p. 1508. Études synthétiques de Géologie Expérimentale, p. 536.

* Comptes Rendus, vol. xciii., p. 794, 1881. This Journal, March, 1882.

BEAUTIFUL MARBLES IN ALGIERS.

The rediscovery of the ancient quarries where the beautiful antique marbles were obtained is interesting. An extensive quarry, covering two thousand acres, has been quite recently discovered in the province of Oran, near the Mediterranean coast, in Algiers. The deposit has been obtained by an Italian, who has constructed roads and begun operations. The deposit contains giallo antico, breccia, and cipoline, besides black and white marble. These fine colored stones can be laid on the wharf at Oran for about one dollar a cubic foot. The beautiful yellow marble, giallo antico, has, until this late rediscovery, been unknown, save by the fragments found in Roman ruins two or three years ago.

HERAT.

WE give a view from the London *Graphic* of this celebrated and ancient Asiatic city, which has of late been brought to special public attention, owing to the threatened war between England and Russia relative to the boundary line between Afghanistan and Russia.

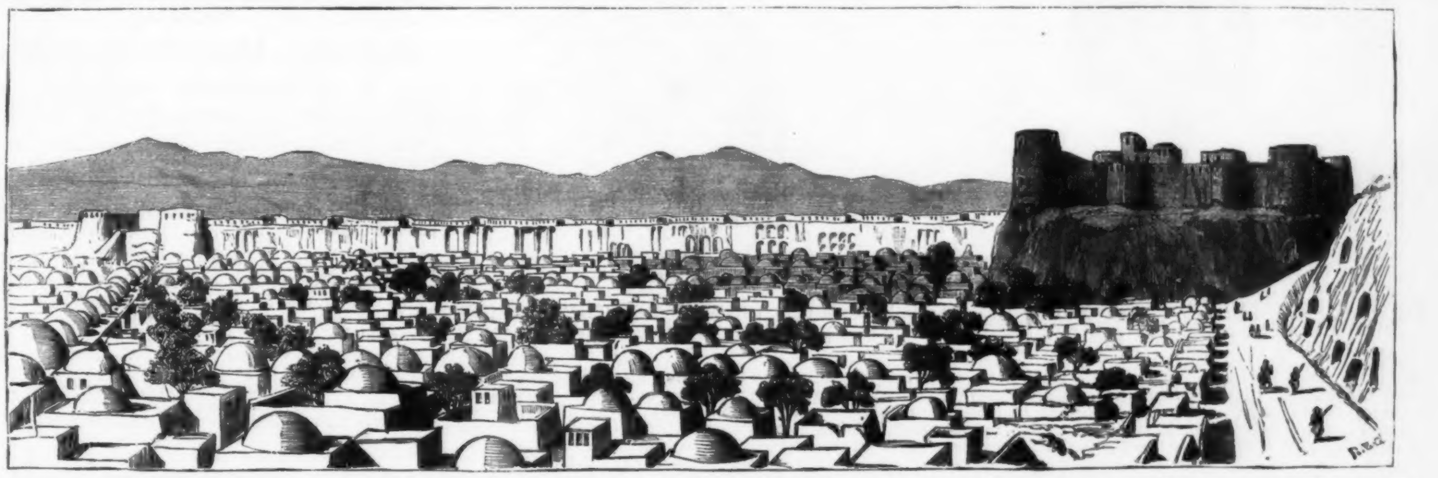
"Colonel Sir W. Ridgeway," writes Lieutenant R. E. Galindo, on November 16, "with a party of officers of the Mission, went into Herat some days ago to pay a sort of farewell visit, and to finally inspect the fortifications, especially the new works which had been constructed under the superintendence of Captain Peacocke. These were completed, and were then being armed.

"We paid a ceremonial visit to the Governor, where the usual cups of sweet green tea were handed round, and a number of presents, consisting principally of silks, furs, carpets, etc., were laid at the feet of the Commissioner.

"The following day we inspected the works, and I was rather struck with the *coup d'œil* from the large tower at the northwest angle of the wall, looking over the interior of the city. The latter, however, is decidedly a mean-looking place, being simply a vast confused mass of mud-built houses and hovels, the majority of which are in a ruinous condition.

"The pleasantest feature of the whole is, perhaps, the number of trees that grow inside the city, and that must give an agreeable look of verdure and shade in the summer, though now of course the leaves are falling fast. Two long streets run from north to south and from east to west, crossing at right angles in the center of the town. These are roofed in the whole way, and form a long arcade, rather dark and gloomy-looking. These two streets form the entire trading quarter of the city, and the only shops in the place are in them. The remainder of the town can hardly be said to have streets at all—simply narrow, tortuous, and filthy lanes, winding among the mud hovels without the slightest attempt at any plan or system. The condition of the whole city is indescribably filthy, and there are absolutely no sanitary arrangements of any kind in existence."

The city of Herat forms a quadrangle of nearly a mile square, on the northern face having a citadel built of sun-dried brick on a high artificial mound. The city is distinguished above all Oriental cities by the stupendous character of the earthwork upon which the city wall is built, the earthwork averaging 250 feet in width at the base and about 50 feet in height, the wall being 25 feet high and 14 feet thick, supported by a great number of semicircular towers. The city has five gates, two on the northern face and three others in the centers of the other faces, and the streets running from these faces meet in the center of the town in a small domed quadrangle. The great mosque, covering an area of 800 square yards, erected toward the close of the 15th century, is now falling into ruin. The principal business of the place is conducted in bazars on the four streets near the center of the city. These are low brick structures of considerable extent, the roofs being of arched brickwork, of the dome-shaped appearance which makes so prominent a feature in our illustration. The mud houses in the rear are in very neglected condition, and are not all inhabited. The climate is one of the most agreeable in Asia, 98° F. being about the extreme of summer heat, while in winter it does not freeze hard enough at Herat for the people to store ice.



HERAT, SHOWING THE FORTIFICATIONS, THE CITADEL, AND PART OF THE INTERIOR OF THE CITY.

THE PROGRESS OF SCIENCE.

THE president of the British Society of Engineers, Mr. P. F. Nursey, in his recent inaugural address, said: The facts I have brought before you also point to the moral and material progress of the world. "The bee that hummed its busy hour through the bowers of Paradise," wrote Sydney Smith, "fashioned its hexagon with the same mathematical precision which it does now and here. Six thousand years have added nothing to the sagacity of the horse or the intelligence of the dog." But how widely different with man! He commences as a fire-worshiper and rises to a Newton, a Faraday, a Stephenson, a Siemens. He tempts the river in a few fragments of bark lashed together with thongs of raw-hide, and crosses the Atlantic in an iron steamer of 22,500 tons burden (the Great Eastern). He burrows in the earth, and then builds a city with 4,500,000 inhabitants. He sticks a dried seed in a lump of fat to light his mud hut, and carbonizes 2,200,659 tons of coal per annum to illuminate London. He takes weeks to send messages on sticks to Montezuma, from the coast, and at last reports in London the details of a battle fought in the Soudan the same morning. He slays his foe with a sling and a pebble chosen from the brook, and meets the enemy with a machine gun firing 600 rounds a minute by means of its own recoil (the Maxim gun). He lays siege to a city with a balista, throwing a fragment of rock, and finally attacks a fort with a gun weighing 110 tons, projecting a steel shell of 1,800 pounds, with a charge of 900 pounds of gunpowder. The ax-head that floated for a few seconds on the Jordan 3,000 years ago, when "the iron did swim," was a miracle indeed. These are the beginnings and endings of science, but they are the endings of science as regards the present only. They are by no means final, for science never stands still. They are but the landmarks of our times, which, as Emerson puts it, are "trivial to the dull; tokens of noble and majestic agents to the wise; the receptacle in which the past leaves its history; the quarry out of which the genius of to-day is building up the future."

THE LURAY CAVERNS.

By GRAHAM LUSK.

THE stalagmitic caverns of Luray were first discovered by Andrew J. Campbell on the 15th of August, 1878. Campbell was one of a party of search organized by Mr. B. P. Stebbins, a traveling photographer, who was convinced that a cavern existed somewhere in the vicinity. A small cave in one of the hills near Luray had long been known, but the discovery of Campbell was a great surprise to the villagers, and it brought to light one of the finest pieces of subterranean architecture in the world.

Luray is situated rather to the north of Central Virginia, in Page County. The surrounding country is a broad valley of rolling limestone, bounded on the east by the Blue Ridge and on the west by the Massanutton Mountains. The cavern is about a mile from the town, is in the middle of the valley, and is about five miles distant from either of the bordering mountain ranges. It occupies a rounded mound locally known as Cave Hill.

The Luray Cave has been hollowed out of Lower Silurian limestone, probably during the Tertiary period, but possibly at an earlier date. First it consisted, perhaps, of a slight fissure with insignificant ramifications, through which flowed water charged with carbonic acid. Little by little the limestone was dissolved, the insoluble carbonate changing to the soluble bicarbonate, and being carried away by the stream. Another active agent in the excavation was the sand held in suspension by the water, which, simultaneously with the solution of the limestone, wore away the sides of the channel by erosion. In the course of time, as the cavern increased in size, the process of excavation was accelerated by the falling of large masses of rock from the roof. After having been the course of drainage for countless years, the channel of the flowing water was altered by some geological change, thus leaving empty vast halls stretching in every direction. The process of excavation being completed, the secondary process of ornamentation now set in. Rain water always contains a considerable quantity of carbon dioxide dissolved from the atmosphere, and this amount is increased when the water comes in contact with the decaying vegetable matter at the surface of the ground. Now when water, charged in this way with carbonic acid, percolates through limestone rock, the limestone is dissolved and held in solution as a bicarbonate. Let this aqueous solution emerge drop by drop on the ceiling of a limestone cavern; coming in contact with the air, it immediately loses a part of its carbonic acid, thereby depositing a minute amount of insoluble limestone, which adheres to the ceiling; the drop hangs a moment and then falls to the floor, still charged with a little of the soluble bicarbonate. By the time it has reached the floor it has lost all, or nearly all, the carbonic acid it contained, and the insoluble limestone takes its place on the bottom of the cavern, to contribute its infinitesimal quota to the formation of a mighty column. Sometimes the water emerges through the ceiling following certain lines, and in this way are formed the beautiful draperies of translucent calcite, which astonish one by the gracefulness of their natural foldings. The Luray cavern after its excavation was subjected to this process of adornment, and many large pillars were formed before it again became a drainage channel, this time for the corrosive mud of the glacial period. The mud darkened the whole surface of the cave, and carved out numerous contortions. When the ice and glacial mud were things of the past, a second growth of stalactitic and stalagmitic forms arose from the dark-brown walls of the cave; many of these formations are of the purest white, while others are colored with oxide of iron. A unique feature of the cave is the presence of *helictites*, which are lateral outputs from the sides of the cave and from the pillars; the cause of these curious grotesques has never been explained. They often surround the columns of the cavern in several distinctly separate growths. Washington's Pillar is highly fluted in this manner, and in the Fish Market these helictites hang over the rock as a fringe, curving so as to remind one of elongated alligator's teeth.

This brief review of the formation of the cave will make more interesting the description of its most prominent beauties. The caverns are illuminated with the arc electric light, and in this way they are seen to best advantage, though the sense of vastness is thereby much decreased. When a couple of candles struggle to dissipate the gloom, the dimensions of the halls seem to be almost limitless. When the cave was first discovered, numerous tracks and indentations were found in the clay of the floor, thus proving it to have been the former abode of wild animals. A part of a human skeleton may be seen imprisoned in that portion of the cave which bears the ghastly name of Skeleton Gulch. The entombed skeleton is of no scientific interest, as its confinement in the tufa of the floor evidently took place at no very distant period. At one portion of the cave we reach a place where the ceiling comes within a foot of touching the floor; here the pathway has been dug out to a depth of three feet.

Hence, we enter a spacious chamber which contains Pluto's Chasm, a deep cleft in the rock, 500 feet long, 70 feet high, and of a width varying from 10 to 50 feet. From the deepest and gloomiest part of the chasm rises a pure white stalagmite called the Specter, which for centuries has haunted the locality with its ghostly appearance. One of the halls is called the Cathedral, and contains a wonderful Stone Organ. This latter consists of parallel blades of stalactites, which are beautifully sonorous when struck. Each blade seems to give forth a different note, and tunes are played upon them, the blades vibrating in low, clear, harmonious tones. Near by are the Chimes, and here again we have evidence of the sonant power of this stalactitic calcite. The Giant's Hall is the culminating triumph of nature's handiwork at Luray. It is a chamber 80 feet in height, and among the multitude of beautiful pillars the Empress Column at once attracts attention. This is a very slightly rose-colored stalagmite reaching to the height of 35 feet, and having a most beautiful symmetry. Near by is the Henry Baird Column, an immense bulwark of snowy calcite. There are many other large columns in the Giant's Hall, and besides all these, the ceiling is an inverted forest of smaller stalactites. There is also the Cascade, a pure white formation resembling a foaming torrent pouring out of the rock. Several of these beautiful cascades are found in the cave, and they are among its finest adornments. The Angel's Wing is an exquisite formation of the purest white, and resembles a wing as closely as if sculptured by a human hand. Many of these names are manufactured to aid the guide in telling his story, but others are wonderfully appropriate. At one point we are shown a Castle on the Rhine, which resembles Bishop Hatto's Mouse Tower. Again, our attention is drawn to a large owl perched upon the side of a stalagmite. One of the marvels of Luray is the Hollow Column, which, in former years, has been the course of a stream of water; this column may be ascended by means of a rope, and 60 feet above the floor, another large chamber is opened to the enterprising visitor.

There is no considerable sheet of water at Luray, but there are several pools of various sizes in which the water is as clear as glass. From these basins crystals of calcite are being deposited by the slow evaporation of the water. While one is walking through the great halls of the cave, he is almost certain to turn his eyes upward to the long pointed stalactites weighing hundreds of tons, and the story is apt to come to his mind how a certain king's subject, in the gratification of his own desire, was permitted to take the king's place at table, and how, when he had half finished the meal, he looked up and saw a sword hanging by a single hair. The cohesion, however, of calcite is very great, and a fallen column is of rare occurrence.

The fauna of the Luray Cavern is very limited. There are numerous spiders, all of which belong to the species *Linyphia weyeri*. There are a few *Spirostrephon copei*, which differ from those found in the Mammoth Cave in having shorter hairs. A myriapod, called the *Syngonopus whitei*, has also been discovered. The fluffy, white growth of mould on the green planks of the walks seems to be the only form of vegetable life in the cave.

In the comparison of Luray with the great caverns of the world, it may safely be stated that no other is so completely decorated with stalagmitic formations. The Mammoth Cave consists of an almost endless series of chambers, stretching underground for miles, while the Luray Cavern has less than two miles of avenues; but in the former cave the halls are vast darkened chambers, whereas at Luray they are delightfully varied and embellished. The finest limestone cavern in Europe is at Adelsberg, in Austria, and this is laid out in walks four to five miles long; Adelsberg is somewhat similar to Luray, and there is one beauty which

the latter cavern does not possess. This is the presence of dry stalagmites and stalactites, which are covered with crystalline faces, and which glisten as though illumined with myriads of diamonds, even with the feeble light given by candles. At Luray there is no flowing water; at the Mammoth Cave some of the halls are still the beds of a subterranean river, while at Adelsberg a deep river, strange to say, enters the mouth of the cavern, falls downward, and disappears, to be heard of no more.

There is something weird and fantastic in excursions through the chambers of solid rock in these underground caverns, shut off, as they are, from all the outside world; it is a feeling of strangeness and wonder, which, after one's visit, becomes a pleasant memory of hours delightfully employed.—*S. M. Quarterly.*

ELECTRIC FISH.

To the laity, electric fish are nothing more than zoological curiosities, and little more can be learned of the electric eel and torpedo, from the papers and periodicals, than that they are organic creatures which, in some mysterious way, are capable of acting like an induction apparatus or an electric machine. Most people are satisfied with this; and if an article on the subject is accompanied by a picture of the wonderful creature, the reader casts a glance at it, wonders at the harmless appearance of the peculiar fish, and thinks he has an idea of its nature. We will try to show by the aid of several cuts taken from the *Illustrirte Zeitung* how little he really knows on this subject, which is worthy of much close study.

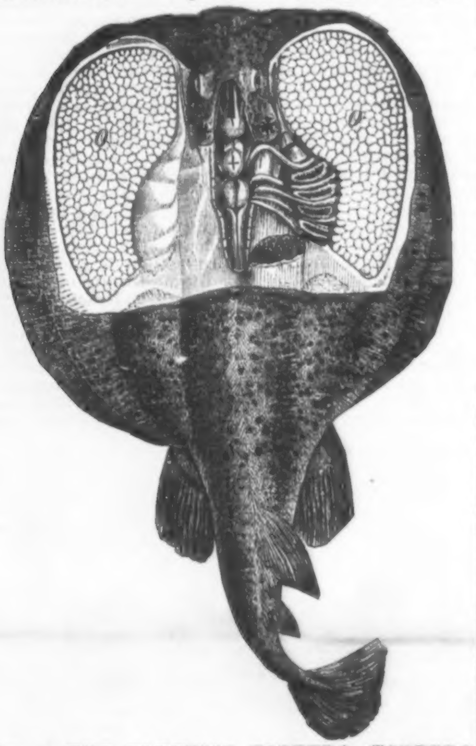


Fig. 1.—THE ELECTRIC TORPEDO (TORPEDO MARMORATA), SHOWING THE ELECTRIC ORGANS, O, O.

We know of about fifty kinds of living electric fish; of these the electric eel (Gymnotus electricus), the electric silurus (Malapterurus electricus), and the torpedo (Torpedo marmorata) are best known.

The position and the nature of the electric organs are very different in the various members of the group of electric fish. In the torpedo the electric organs (Fig. 1, O, O) lie one on each side of the skull, between this and the pectorals, and are composed of numerous perpendicular columns separated by membraneous partitions. Each column is divided by cross partitions of membrane into cells, each of which contains alternate layers of granular nerve filaments and gelatine. Every cross plate contains a network of nerves, and this network spreads out to form the "electric plates," which, as experiments have proved, are always electro-negative to those surfaces which are not provided with nerves. Fig. 2 shows a cross section of a torpedo, from which we learn that the columns of the electric organ become shorter toward the outer edges of the fish's body. The electric power which can be produced by these organs is so strong that the shock received from large specimens of the Torpedo occidentalis is strong enough to throw a man down.

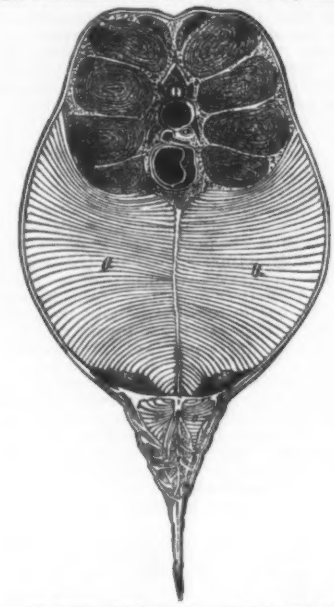


Fig. 4.—CROSS SECTION OF AN ELECTRIC EEL. O, O, ELECTRIC ORGANS.

Fig. 6.—CROSS SECTION OF THE MALAPTERURUS. O, O, THE ELECTRIC ORGAN.

Let us compare the electric eel of America, a fresh water fish, with the torpedo of the ocean. The former, which is shown in Fig. 2, has nothing in common with eels except its shape. As is shown in Fig. 4, which is a cross section of an electric eel, the electric organs (O, O) occupy four-fifths of the body, the other organs being crowded into the remaining one-fifth. Instead of the polygonal columns which are perpendicular in the torpedo, we have here low broad prisms, which are placed horizontally. There are very large specimens of fish of this species, some having been found which measured about 2¾ yards, and weighed 40 lb. The electric power of these eels is as great as that of the torpedoes, and makes them so dangerous to horses and mules employed for carrying burdens across the rivers that roads have had to be changed, so we learn from Dr. G. Fritsch, because certain fords had to be abandoned on account of the great number of electric eels encountered there.

There is still another electric, fresh water fish, which is as powerful as the gymnotus; this is the electric silurus (Malapterurus electricus) of the Nile, shown in Fig. 5. It is characterized by the worm-like appendages which surround its mouth and serve to draw in its prey. While the other members of the siluridal family have wide jaws, the electric silurus has a small mouth and very small teeth, from which it is supposed that it lives on small crabs, fish, and worms. The temperament of the malapterurus, as well as of other electric fishes, is phlegmatic; they wait quietly under stones or in the mud for an opportunity to use their weapons. In Fig. 6, the arrangement of the electric organ in the malapterurus is shown. It does not lie in the interior of the body, as in the gymnotus and torpedo, but between the skin and the muscles, and the construction of the organ is quite different from those of the fishes described above, as is the connection with the central nerve system.

The complete electric organ is quite incomprehensible to the human understanding, and the only way in which we can hope to form any idea of its nature is by a study of the development of organ and the elements from which it is formed. Two investigators, De Sanctis and Babuchin, have done much toward the solution of this question, for they have found that the electric organ in the embryo torpedo resembles closely the first muscle cells, from which they conclude that the mysterious galvanic batteries are muscles which have undergone a change, and this has been proved to be the case. In electric fishes the electric organs occupy the spaces which in other fish of their species are occupied by muscles.

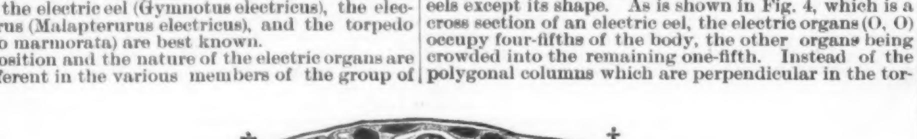


Fig. 2.—CROSS SECTION OF A TORPEDO, SHOWING THE ARRANGEMENT OF THE COLUMNS IN THE ELECTRIC ORGAN.

Fig. 3.—THE ELECTRIC EEL (GYMNOTUS ELECTRICUS).

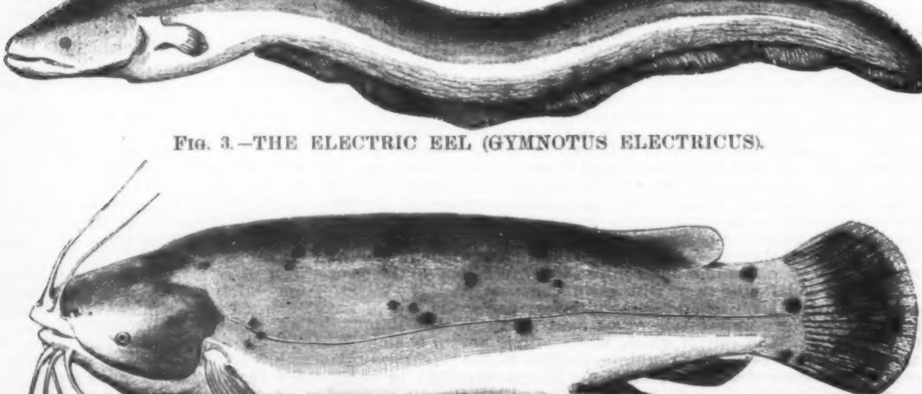


Fig. 5.—THE ELECTRIC SILURUS (MALAPTERURUS ELECTRICUS.)

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